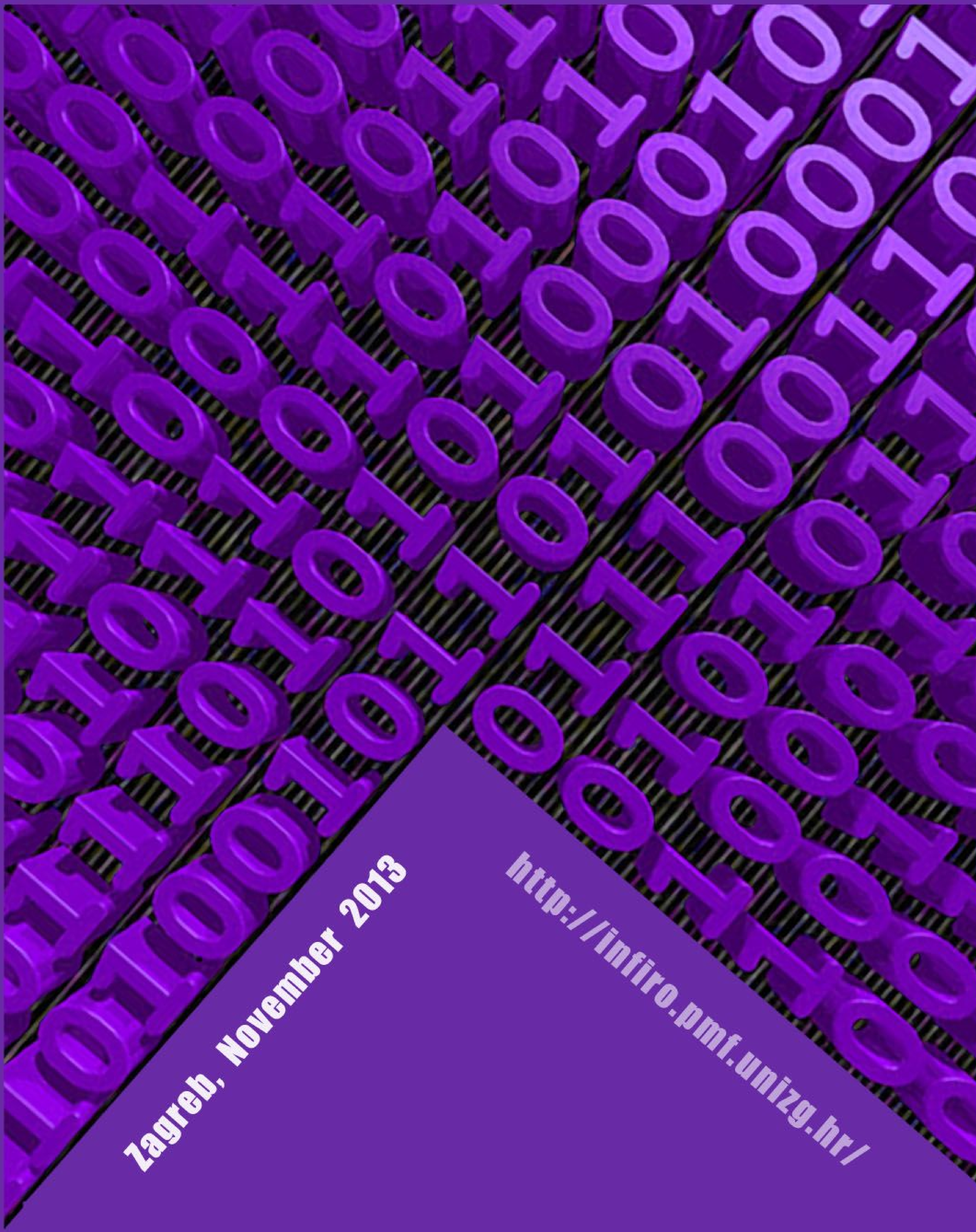

Zagreb, November 2013

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INFIRO Proceedings

of the International Conference of Robotics, Electronics and Computerized Laboratory

INFIRO Integrated Physics Approach to Robotics Designed Laboratory

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INFIRO project (Integrated physics approach to robotics designed laboratory) was conceived as a lifelong learning programme primarily dedicated to students in vocational schools aiming at developing their expertise beyond the scope of regular education curricula. Applying interdisciplinary approach and combining different electronics, mechatronics and robotics problems with more fundamental physics, mathematics and informatics knowledge we promote scientific and technical education, both, to primary school pupils and high school students population not only those from vocational schools domain. All our activities truly happened in the strict laboratory environment equipped with computers and suitable electronic elements/tools and controllers. We minimized the foreknowledge requirements in favor of the student's self-investigation approach. Our activities did not pull out teacher component away from the education process, on contrary, our laboratories strongly depend on teachers always being present to help and give constructive recommendations and clues instead of the unnecessary lessoning.

During active period of INFIRO project two Summer Schools were held in Rabac/Labin with more than 60 students and 30 teachers/trainers being present at each school. But in the event preparation hundreds of students and dozen teachers and trainers from different countries were involved in diverse types of activities: from problem construction, machining and testing equipment to designing and shaping educational materials, developing and performing the laboratory learning.

We experimented with numerous apparatuses to make our laboratories as attractive as is reasonably achievable. Sometimes very novel tools were used and occasionally we grabbed the software well known for decade. Crucial decision point in our exercises was always the motivating idea of the experiment. For basic robotics and electronic lab we tried to use the most reliable tools, minimizing financial requirements and making things easily available to wider population interested in a subject. However, inside advanced lab in electronics and robotics we were not afraid to practice with a more complicated, sometimes even commercial, hardware and software.

This book is collection of ideas partially or completely covered on INFIRO Summer Schools or around it. It contains our experience on exercising with electronic circuitry and trying to pull out some intelligent action from simple controller board. If you, because of this booklet, desire to acquire some of the available controllers on the Internet and start to practice yourself trying to beat novelty of our skills and ideas, our mission is completed. But a lot of INFIRO ideas are yet neither realized, nor published. Many things are not realized yet so we hope that we will be back.

Zagreb, December 2013.

Prof. Darko Androić, INFIRO project promoter

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Robotics summer camp – opportunity for talented pupils

Tomaž Kušar
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Despite robotics being an optional school subject in primary schools for pupils aged 14 or 15 years, it is recently becoming more and more popular. Pupils participating in robotics are enraptured with technics and engineering, some of them even programming. But teaching robotics is largely dependent upon equipment available to the teacher. Meaning that teaching contents are adjusted to the curriculum, which in reverse depends upon the equipment the teacher has at one's disposal. For these reasons complex aims, which are also part of a curriculum, are usually not covered in classrooms. Robotics summer camp is therefore an excellent opportunity for pupils, interested in robotics. Within these workshops pupils learn not only about the basics but also complex applications, like IR remote control, driving stepper motors, PWM and others. Robotics summer camp can also serve as a research paper springboard for some pupils. The paper concludes with pupils' reports on robotics workshops, where they were programming eProDas-Rob1 interface in BASCOM and Visual Basic and built constructions with Fischertechnic set.

1. Introduction

Robotics is one of the optional school subjects in Slovenian 9-grade primary schools [1] being elected by 8th or 9th grade pupils. In spite of that, it is a complex and interdisciplinary science, which is becoming more and more popular in Slovenian primary schools. Old-fashioned robotics sets have been replaced by new improved sets with specific sensors, building pieces, like new Fischertechnik sets or Lego Mindstorm set which include almost professional interface with ARM processor. Especially the latter has recently become the most popular or widespread robotics set in Slovenia. Also more and more schools are included in the well-known First Lego League competition on an annual basis. This competition is an eminent opportunity for pupils who wish to improve their skills and knowledge. So these two sets offer much more than the pupils are able to use. In spite of all that the robotics is still relatively poorly represented in Slovenian primary schools. Maybe it is because Lego sets are too expensive for many schools to afford them. Another question is whether the teachers of technical engineering are qualified enough to instruct robotics? Based on pupils' feedback from robotics summer camp it is evident that pupils in primary schools do not deal with more complex tasks such as driving servo motors, familiarize themselves with PWM or IR remote control [2]. Furthermore, pupils often do not know what voltage divider is, whether it consists of two resistors in series or a potentiometer. Teachers usually do not mention light dependent resistors or transistors used for light sensor. What they present to pupils is a light sensor like "black box", which can detect light or darkness. They often do not mention worm gear pair too.

Finally, computer scientists who see it as an opportunity to learn the programming languages often teach robotics in primary schools. Such teaching often gets out of the curriculum content. Robotics is not only about programming but also much more - it deals with electronics, engineering and physics. The question is what kind of robotics' contents is really appropriate for pupils or even more, talented pupils? To conclude, the fact that robotics' competitions for primary school are still poorly visited remains.

2. Robotics projects

One of the main tasks within the optional subject robotics in primary school is to make one's own constructions and write or just use appropriate working program making it. But before pupils undergo the task of their own project, they have to become familiar with the basics of programming structures and algorithms as well as principles of digital and analogue sensors and actuators. Under the teacher's guidance, they usually build some models like bar barrier and simple mobile robot (line follower). Through these models they can adopt all the basic concepts that are later needed when building their own construction. They familiarize themselves with warm gear advantages, tooth gearing, V-belt pulleys and so on. At the same time more motivated pupils are given the opportunity to upgrade and improve their models with additional sensors or actuators. But within these robotics lessons pupils often do not dwelve into the sensors' details and actuators. They just have to be familiar with how to use them in a specific situation.

Fig. 1. Mobile robot with ultrasonic distance sensor or light sensor.

Fig. 2. Bar barrier is an example on which pupils familiarize themselves with warm gear advantages.

Rarely do teachers analyze light sensors such as circuit by connecting a resistor in series with the LDR. Neither do they analyze servo nor stepper motors. It is all due to the fact that they often do not have enough time or equipment. Finally, these contents are meant for more successful pupils. But in case the teacher uses a more "open" construction set such as Fichertechnik it is easily possible. They can easily add an additional sensor or homemade sensor, which enables them to explain the concepts given there [3]. Things are made more difficult when one wishes to add homemade sensors to LEGO sets; however, it is also possible to do [4]. In the latter case, the sensors as well as motors are "black boxes". The pupils don't think about six wires on DC motor. But it is also possible make homemade sensors. But for many teachers teaching the principle of DC motor operation let alone sensor's operation is not the point of robotics in primary schools, in spite of the fact that our curriculum dictates these contents. Teachers usually just want to familiarize the pupils with robotics. They also encourage them for robotics competition such as FLL, RoboCup and so on. But still, sometimes pupils would like to understand the basic principles of electronics background and they are not given the opportunity to do so.

3. Robotics summer camp

At this point we can mention some especially talented pupils. It is typical of these children that they usually quickly find the solutions and often feel bored. These pupils quickly stray from the path too. From the teacher's point of view it is impossible to satisfy the needs of everybody in the classroom. That is why the robotics summer camp is an ideal solution for these children.

I have some personal experiences from robotics summer camps where I led both, one year the classic robotics group and two years a research robotics group. As a teacher I can say that these workshops are really suitable for talented and motivated pupils. And finally, I have worked with my pupils too, from our primary school, and for these reasons I can easily compare school and robotics summer camps' work. The latter way of work brings many benefits:

- Pupils work in small groups, in couples or individually, therefore the teacher can devote more time to every individual pupil.

- They can familiarize themselves with some specific sensors such as ultrasonic distance sensor, IR distance sensor or specific electronic elements such as LCD display, stepper motor, servo motor, computer keyboards, numeric keyboard and so on…
- In order to program robots free software (BASCOM) and open hardware (eProDas) are used – it means that pupils later can freely download and use them at home [5], [6].
- They learn about specific and complex algorithms.
- They familiarize themselves with specific microcontroller functions such as PWM, UART, SPI, interrupts…
- Pupils have many instruments at their disposal, such as oscilloscope
- They can devote all their time to one specific problem only.
- In case a participant encounters a problem and needs help, the mentor can immediately come to one's assistance.

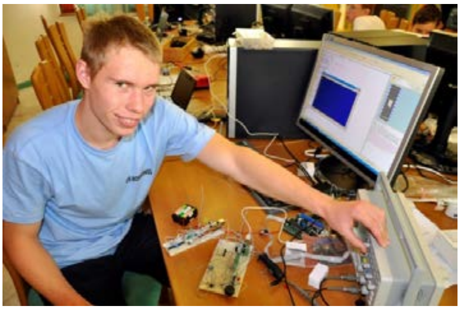

Fig. 3. Pupils can use professional oscilloscope.

Fig. 4. They build electric circuits on protoboards.

However, robotics summer school did not only possess the above-mentioned benefits. There were many others as well. All children participating at this summer school share the same interest – to acquire knowledge. They encourage each other and help each other. They are all friends and share the same views and work as one. Nobody laughs at one another; there is no time for off-topic questions. Due to all this, the working environment is really stimulating. This summer school also has a huge didactic value. According to the concept of summer school pupils create a stand-alone project in the robotics group as well as research group. Both groups present complex final projects. Constructions consist of many building parts, sensors and actuators (Fig. 5., 6.). The last few years have seen many fantastic and amazing projects [7, 8, 9].

Finally, the intention of summer school is to encourage pupils and students to engage themselves in research work especially those who participated in a research group. Research group otherwise consists of pupils who already have some experience in robotics and who are already familiar with the basics of robotics. Before these pupils can take part in a summer school they have to choose a specific problem, which they try to solve later. Mentors can prepare the materials and the needed tools and instruments in advance. When summer school closes its doors, a pupil can continue with his or her (research) work. There is one disadvantage, namely in many cases a mentor loses contacts with the pupils when summer school is over.
Based on my personal experience I can say that one of my pupils really did continue with her research work. She prepared research starting points and started with the research work after summer school. She is extraordinarily talented and her research work received a prize on the Slovenian competition for young researchers. She also participated in Expo-Sciences Europe.

This presents one more reason why robotics summer camp really is an excellent opportunity for talented pupils.

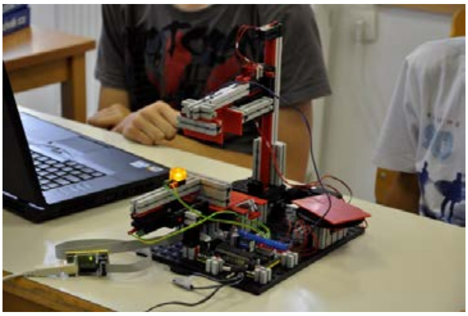

Fig. 5. Complex construction - sorting machine.

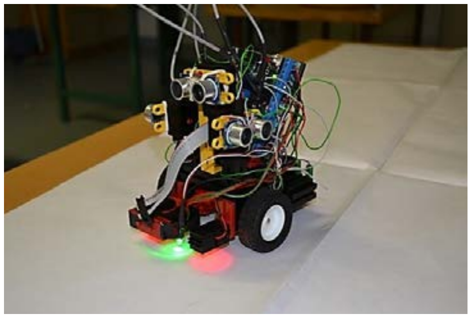

Fig. 6. Mobile robot with three ultrasonic distance sensors and three color sensors.

4. Results and conclusions

Although teachers try to adapt the robotics contents again and again, they are often unable to fully meet the needs of talented pupils. The fact is that primary schools are not equipped with professional instruments such as oscilloscope, and other materials such as protoboards, measuring interfaces, multimeters, sensors, specific construction sets and others. Summer robotics camp offers all these and more. There is even an organised excursion, which takes place within the project week. The questionnaire delivered to the pupils after the robotics summer camp provided us with a remarkably positive feedback. Some of their opinions are gathered in reports [7, 8, 9].

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Mentor's experiences with different curricular and extra-curricular activities in robotics

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All the knowledge and experiences allow a mentor to have a deeper insight into an activity. A mentor can direct the participants of different activities of robotics (technical days, interest activity, optional subject, summer school etc.) to a right direction. He can advise correctly and direct participants, he helps them with a project, and meanwhile, he gains new experiences. All the experiences are indispensible because they enrich a mentor him/herself and the participants of the activity, as well. In the article I present the experiences which I gained at various curricular and extra-curricular activities of robotics.

1. Introduction

I had a lot of luck to be invited to cooperate with my professor during my education. I had a chance to get an opportunity, in such a short period of time, to perform Robotics in various curricular and extra-curricular activities and get to know how they are carried out. First, I met Robotics as a subject of the full-time study in the Faculty of Education, and secondly, as a form of a technical day in the 9-year elementary school, as an interest activity, as an optional subject called Robotics in technics, and finally, during the summer school of Robotics. Later, I will present different activities and how I obtained some experiences as a mentor of different activities; I will also describe the advantages and disadvantages of performing all these activities.

2. Robotics in different curricular and extra-curricular activities

Curricular and extra-curricular activities differ in their length and who they are aimed to, in their purpose and in the precise definition of educational standards.

2.1. The activity day – the technical day – an opportunity for new didactic methods

The activity days are those parts of the primary school compulsory programme that cross-curricularly connect disciplines and subjects from the curriculum. They are carried out according to the school syllabus where their content and performance are defined. The objects of activity days are to enable the pupils to deepen their knowledge and connect it with other subjects and specific areas, use that knowledge and upgrade it with the practical learning in the frame of mutual cooperation, and respond to the real events in the limited or wider social context. [1]

The technical day – Robotics is aimed at the pupils of the third cycle of the nine-year primary school. Usually, it lasts just one school day, or five periods, which is too short to enable the pupils to do a project, as they would like to because they do not have knowledge to be creative on their own. The teacher-centered approach and a pair work are most widely used, learning is in most cases experiential. According to the mentor's instructions, made on the basis of the data with a programme prepared in advance, the pupils try to determine the properties of a programme and logically complete it. The barrier with the traffic lights was made as a product of the technical day, controlled with the help of a computer. The Visual Basic software environment was used for programming.

Technical days are ideal for obtaining first experiences because pupils do things according to in-advance determined programmes, which are properly changed or completed. A beginner can try him/herself in the role of a co-mentor and just observes the course of the work. In this case, he/she comes across the most common mistakes in programming and building blocks; he/she can learn what could go wrong when leading the following workshop. As he/she is not limited by any formal rules in this area, such as curriculums, he/she can use non-standardized didactic approaches. It has been shown that during the following technical days it would be good to introduce the internal learning differentiation and adapt it to a pupil as an individual. A class in a randomly formed group should be adapted to pupils with different learning abilities. This is why in the next year's technical day few things changed. The pair working remained but it was adapted to pupils' own abilities and pace. The programming was made in the Bascom-AVR software environment, which enabled the off-line communication. The pupils were extra motivated because the robot, which was made at the end, worked autonomously and it did not need any additional electric leads except the plugging to the electric network (somewhere it was even replaced by batteries) and it did not need any other leads. The e-material for robotics in the Bascom [5] software environment used by our pupils offers them the elementary tasks and the beginning steps of the function of the interfaces, diodes, lights, one-way motor and switch and step by step they made a robot. The mentor is presented in case something goes wrong or if pupils have something to ask him.

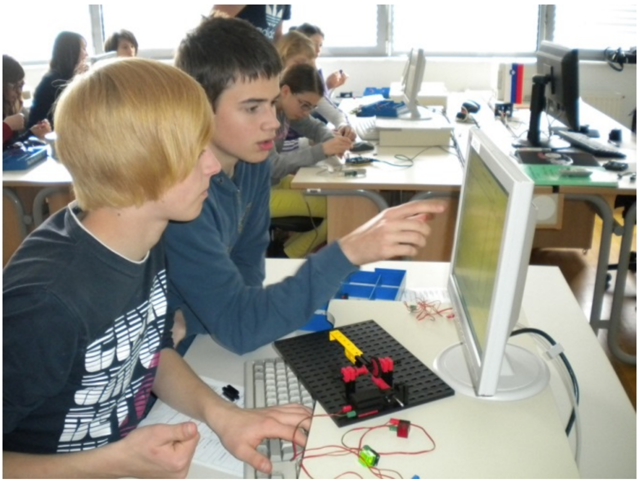

Fig. 1. The participants of the technical day research by themselves with the help of e-materials

2.2. The interest activity - Robotics – An opportunity for being creative

Different interest activities are also one of the activities in the primary school compulsory programme. Its syllabus is not determined so the educational standards are not defined as well. Pupils are not evaluated for their work, the participation in the activity is not obligatory so it is not evidenced in any kind of documentation, which lists or tells the pupils' progress. [2]

The interest activity – Robotics is aimed at the pupils from Grade 7 on. When performing the activity it is important to adapt the pace to pupils, which is not difficult as we are restricted by themes which need to be dealt with. According to my experience, pupils work in pairs, some want to work individually. When making a project, especially during the beginning periods, pupils combine their theoretical knowledge with the practical one and that gives them some additional motivation. At the end they write a resume, take some photos of their product, record its function and write a final report.

Pupils of this interest activity have a possibility to plan a programme. The mentor who tries to include them as much as possible inspects their ideas. By doing this, the grounds for pupils' further motivation are established. This is not possible in a classic lesson because a teacher needs to follow the syllabus of the subject.

Mentor's role in the interest activity is of great importance right at the beginning - in organizing it. Here and with the final project the mentor’s experiences are extremely important. Sometimes pupils have ideals which are not realistic but they can be changed with the mentor’s help in the way they remain interesting and possible to perform in the school environment (number of blocs etc.).

Fig. 2 : A crane made by a participant of the interest activity

2.3. An optional subject – Robotics in technics

An optional subject – Robotics in technics is a one-year long optional subject, which can be chosen by pupils of grades 8 or 9. The focus is on the construction of models of machines and devices, which are controlled by a computer with the emphasis on the specifications of robotics. Pupils learn about the different ways of using the computer technology, key word in robotics and in manufactory controlled by computers, they make schemes of electric controls and they understand their function, they plan and make models controlled by a computer, they obtain the basic methods and ways of work with the help of the project and experimental work, they know what is the role of the computer interface in the machines and device controlling etc. [3]

The pupils can express their wishes here as well, but the mentors of the optional subject must follow the syllabus and work in accordance to it. However, if an individual pupil has an interest he/she can learn a lesson in details, while minimal learning standards are demanded to be achieved.

Mentor evaluates the pupil's knowledge of the Robotics optional subject according to his/her cooperation in a group, according to the oral, written or graphic communication and also according to his/her following the instructions, making decisions, planning, searching for information and evaluating the results of the work, the quality of the final product and time spent. [3]

Fig. 3. Cooperation of pupils in the optional subject

2.4. Robotics summer school – the beginning or the continuation

The summer school usually takes place during the school holidays – from mid June to the end of August. They are aimed to get more familiar with a topic, to deepen the knowledge and to deal with a lesson in details. They are organized by universities, research and other institutions (common societies, companies etc.). [4]

The robotics summer school is intended for pupils aged 12 to 18 who met robotics in any kind of activity, and for those who do not have this kind of experience. In the first summers schools the participants could only attempt the elementary workshops in robotics, but in the past three years the workshop called electronics with robotics – researchable level - has been offered to the participants who want to cooperate again. In this case an individual chooses a project, a mentor prepares appropriate elements and accessories, and during the summer school a participant does researches, upgrades his/her knowledge along with the mentor's help.

According to my experiences, a lot of good projects were done in summer schools. Often I am surprised as a mentor how great their ideas are – but sometimes they can be unrealistic. We find together an optional solution, which is later realized.

To realize his idea a participant helps himself with some carton. He made the labyrinth – a game in which a player leads the ball to the end with the help of switches.

I got most of my experiences in summer schools where I could come across some great ideas, but for their performance you need to sometimes cope with new challenges. The collection that we use during our work offers the basic blocks, which give participants a lot of possibilities for making a project. They are not restricted by half-made works, which are later connected with leads, and I find this very important when talking about children's creativity.

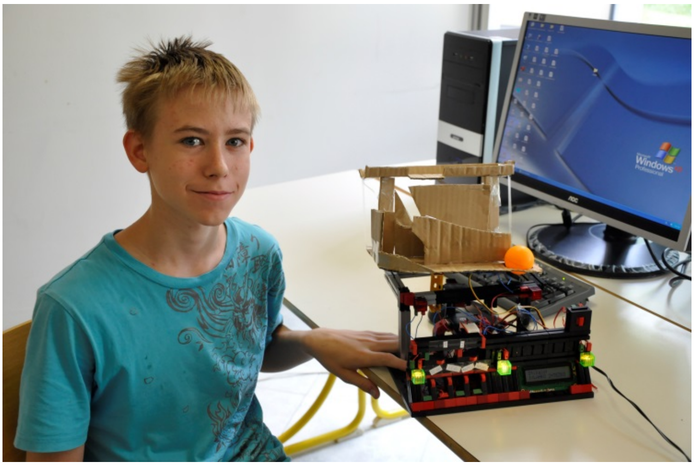

Fig. 4. A game *Labyrintonator* made by a participant

3. Results and conclusions

When programming, as a part of Robotics, a comma or a lapse can quickly disappear. Because of the mentor's lack of experience, just a slight mistake can occupy him and his pupils for quite a long time. Experiences are of great importance because they help a mentor to react quickly, they help him to pose a question to the pupils which leads him to a solution, it gives him new ideas, new directions. A problem can also occur when building blocks or somewhere else.

There are a lot of curricular and extra-curricular activities. The best activity for the beginners is a technical day, when a beginner can cooperate as a co-mentor; meanwhile, he learns new things and gets new experiences. He can focus on the typical mistakes made by pupils, he can observe how the technical day is performed and what still needs to be emphasized. The main advantage of an interest activity is that there are no guidelines determined in advance, but themselves choose them. Therefore, the emphasis is on the topic, which is more interesting for the pupils. The optional subject can also give us a guideline, which is great for the beginners, but in opposite it can present a restriction to mentors who deal with it for a long time. The Robotics summer school is also a great opportunity to get some experiences because its participants give us new challenges to enrich our knowledge.

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Pedagogical approach employed at international group of robotics

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We live in a modern world of technology. Robots got their role in films, computer games; they are becoming a part of everyday life through sophisticated devices being introduced even for housekeeping works, to which contribute the most well-educated technological engineers. If we want to encourage innovations and advancements in the field of robotics, we have to motivate students to educate in this field. There are many ways to increase motivation of students in the field of robotics. You can organize a one-day *technology day of robotics* in schools, *summer school of robotics, ...* However, when it comes to introducing robotics principles to international students, it is not so straightforward. In this paper, we highlighted the problems that arise in the conduct of international groups of students. Teachers leading international groups should be aware that this requires a different pedagogical approach and, consequently, educational methodology, as usual teaching lessons. Among the many additional problems that may arise in the conduct of international student groups, we selected three main: *students' integration problem, student problems with understanding of the speaker* and *prior knowledge of students*. For each of the following problems, which we encountered when we were teaching an international group of International Summer School of Robotics, Electronics and Computerized Laboratory in Rabac, we have listed a few ideas/tips that can serve to help beginners in teaching international groups. Of course, we must not forget the presence of mentors from different countries, which is a great help in managing their international students.

1. Introduction

This paper offers potential solutions to some of the problems that can arise in teaching international group of students [1]. This solution contributes to the rapid progress of students and, consequently, to reach higher standards of knowledge and technological literacy [2]. Problems can arise from both the students' and also from the teacher's point of view. Some of the problems of international students' are: when they first arrive, they are difficult to integrate into a group of foreign students; they may have difficulties segmenting the stream of sound from the mouths of native speakers into recognizable words and they may not be familiar with numerous aspects of speakers' culture. Some of the problems of teachers in international groups are: they cannot know the prior knowledge of students; they are not familiar with the pedagogical approach that students have received in their home countries.

2. Students' integration problem

Participants in an international group of summer school of robotics were students from Slovenia, Croatia, Romania and Turkey (Fig. 1, Fig. 2). At the beginning, they're difficult to engage in talks with foreign students (to integrate into a group of foreign students).

Fig. 1. International students from Slovenia and Croatia

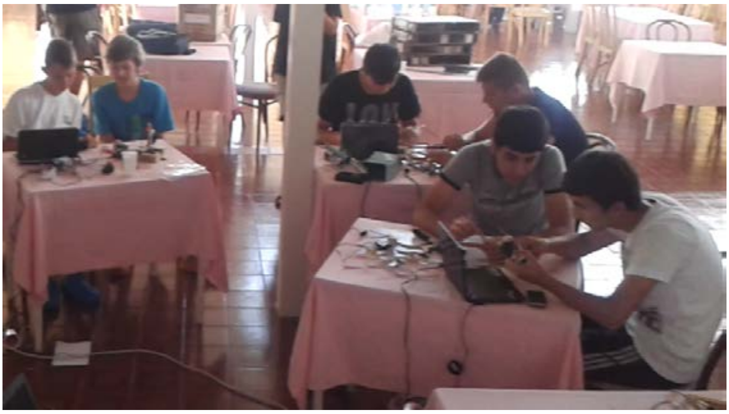

Fig. 2. International students from Slovenia, Romania, and Turkey

2.1. Issues

Many international students did not have experienced these activities before and may not be equipped with the skills to participate effectively at the beginning of their studies there. They were often hesitant to take part in group discussions. In my opinion in most cases, this was due to a lack of confidence and their unfamiliarity with this approach to learning, rather than any lack of academic ability. They may need more time to prepare their answers to questions, or they may felt that the tutor and other group members didn't value their contributions to the discussion. Some may felt awkward in expressing themselves in front of others.

2.2. Solutions

It is good to use icebreakers in the first session to help students to get to know each other and start talking to each other. It is important that all students feel included in the group and are relaxed about talking in front of the others. Explain that, at least in the early stages, they will be allocated to groups and that groups will change. This will ensure that students will mix and get to know each other. It will also avoid the possibility of the early exclusion of some students. Make sure that the groups are small so that a student cannot sit back and let the other students do all the talking and thinking. If necessary assign roles to group members, if they are not able to do so themselves: e.g. discussion leader, programmer, compiler,... Make sure that these roles are rotated among group members [3].

3. Students' problems with understanding of the speaker

The main aim of this chapter is to highlight the possibilities for misunderstanding in any cross-national communication.

3.1. Issues

It is important that international students and their teachers are aware of the possibility for misunderstanding when communicating with each other. This is not just a question of language but of ways of thinking and behaving. It is clear that anything, apart from the most basic of communications, which is common in learning robotics, can often be subject to a number of interpretations. Sometimes there will be a problem of understanding language, but cultural differences may also be playing their part. It is important to be able to perceive whether a cultural difference lies at the heart of a problem. Misunderstandings and confusion may be even more likely in cross-cultural communication. This is the reason why non-native speakers of English may fall behind in class participation, especially in the beginning days. [4, 5].

3.2. Solutions

Remember to wait before moving on to another student, as it can take time for international students to understand the question, consider their response and communicate that in English.

When explaining a concept or assignment that students must understand:

- repeat it,
- slow down in saying the key words,
- write it on the blackboard or provide a hand-out with the information in written form.

If teachers are using PowerPoint slides, the slides should be given to students as a hand-out. In that case, the information actually goes much more quickly than in the chalk-n-talk mode where international students may have a difficult time processing information and getting it down in notes [6].

4. Prior knowledge of students

Teachers' knowledge of students prior knowledge is crucial in making lesson plans, but impossible in the case of entry into teaching international groups.

One idea to help tackle this problem is to regularly identify the skills you want students to learn and apply, being very explicit about the extent to which students need to absorb material and the extent to which they should question material presented.
Incorporate checks for comprehension into the classroom presentation style. Checks that can identify gaps in preparation for all students include:

- asking students to paraphrase or apply ideas, and check for comprehension,
- frequently checking to ask "what questions do you have?" (not just "do you have questions?"),
- asking students to write down the concepts, events, or other references you make that they are not familiar with, to clarify later,
- using other classroom assessment techniques [7].

Be very explicit about your classroom practices including:

- expecting students to ask questions if they do not understand,
- valuing differences in student experience and preparation.

Be prepared for gaps in understanding and view them as opportunities for review, collaboration and discussion [8].

5. Results and conclusions

International Summer School of Robotics, Electronics and Computerized Laboratory in Rabac was composed of students and mentors from four countries (Slovenia, Croatia, Romania and Turkey). Students were making robots composed of collections *Fischertechnik*, which were programmed via a control unit named eProDas-Rob1. At the beginning of communication between students from different countries did not took place, but later there have been small talks [9].

Much helped the fact that two teachers guided the students. One of the teachers was constantly available for the Turks and Romanians, and the second teacher Slovenes and Croats. If I would lead once again an international group, I would like to try the methods listed in this article (test the theory in practice).

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Student activities in electronics course on international summer school of robotics

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In this paper we summarize the conclusions of student activities in electronics course on international summer school of robotics in 2012 and 2013. We especially concentrate on how lecturers provided content, on type of student activities that were involved in learning process and how we achieved high student motivation. There is also explained what kind of software was used and the purpose of using it. An example of problem-based exercise showed very good student motivation and knowledge output, although this was not tested. The statement lies on observation of lecturers and the outcome: the projects that were made in summer school, which are innovative as well as imaginative.

1. Introduction

Many children are big fans of different electronic devices. Not only that they use them, because of their imagination, they also contribute to their development. Since the inspiration and motivation are the key elements for future innovators, engineers and programmers, we have committed to offer students opportunities to gather some experiences that hopefully will be useful in their future. In the group of electronics were participants from Slovenia and Croatia. Since the language presented an issue, we tried our best to explain everything in two languages. Our colleagues from Croatia were helpful and sometimes translated from Slovenian to Croatian.

2. Working material

Working material consists of instructions and associated electronics kit, which has been assembled for the educational purpose in the first steps of electronics for students aged 12 to 17 years. Instructions with minor changes are now used for four years and are still work in progress. Electronics kit consists of different electronic elements, for example resistors, capacitors, LDR, NTC, some integrated chips, LED-s, diodes, buzzer, lamp, potentiometers, switches, prototype board and wires (Fig. 1.).

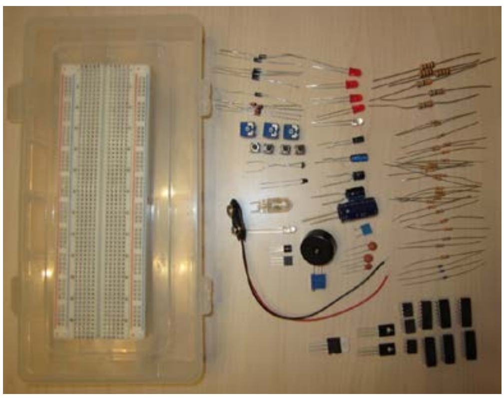

Fig. 1. Electronics kit

There has been already some research done on how the students find instructions with electronics kit. Mostly they find subject interesting and instructions as illustrative as useful [1, 2]. Online are many offers for various electronics kits, but most of them are expensive or do not have instructions, in some of them the teaching approach in inappropriate [3, 4, 5, 6].

3. Working methods

The "old" way of teaching, where students were simply listeners and lecturers lectured is obsolete. Because the lecturers are in the center of learning process and students are not actively included in learning process, they are not motivated. In order for students to gather as much knowledge and experiences they have to participate and be in the center of learning process. The best way, as we see it, is to use student-centered methods, where students are actively involved and they determine time schedule. The teacher must have a great deal of expertise, since he can never really know where the students will lead him. Such teaching is demanding and very complex.

We concentrate on experience-based learning; some will call this learning-by-doing. Students are in the center of teaching and learning process; they gather experience through student's participation in activities [3, 4]. There is as much as possible little theory and a lot of practice. This way, rather than memorizing rules and characteristics, they get the knowledge by doing some simple tasks. This kind of learning is a part of so-called student-centered methods that also implement problem-based learning and project-orientated learning (Fig. 2.).

Fig. 2. Working atmosphere in the electronics group

4. Students motivation

In experience-based learning teacher concentrates on students' activities rather than his lectures. The logical consequence of that kind of teaching is higher motivation, which only rises when we use problem-based learning and in the second part of electronics course, we get student innovators with project-orientated learning.

To be up to date, computer simulations and programming is also implemented in electronics course. Simulations are made in Yenka [5] that is free for non-commercial home usage and programming, also free, is done in Bascom AVR [6]. Simulation tool Yenka Technology is user friendly and it can provide us with designing and simulating circuits using over 150 types of component, testing and refining design as we work, converting circuits into 3D PCB simulations, PIC programming and experimenting with a range of mechanical inputs and outputs in full 3D. On Fig. 3. we can observe diagram that can lead us to student motivation.

Fig. 3. Block diagram of student motivation

To make exercises more appealing and students as much as possible motivated, we try to integrate variety of sensors, such as light depending resistor - LDR, thermistor - NTC and magnetic sensors. All the exercises were designed to fit our requirements, especially to gather knowledge empirically.

5. An example of problem-based task

One of the exercises is electronic circuit that alerts us when someone comes along. The warning is in the form of light emitting diode – LED. This task is in the middle of the first part of electronics course, so students already have some knowledge about sensors, resistors, capacitors and some other electronic elements. With the help of their past experience and the use of simulation program Yenka, they construct electronic circuit (Fig. 4.). This circuit, which is basically an operational amplifier voltage comparator, compares voltages on negative and positive input. There is only one binary digital output, which can be ideally, in our case, 0 V or supply voltage +5 V. Since the simulation predicts voltage drop, the output is 0 V – digital 0 or only 2,8 V – digital 1. There is simple rule to determine whether there is 0 or 1 (Eq. 1.).

$$V_{out} = \begin{cases} 0, if\ V_{in-} > V_{in+} \\ 1, if\ V_{in-} < V_{in+} \end{cases}$$

Eq 1. A simple rule to determine digital output of voltage comparator

On Fig. 4. we observe three voltages; on negative input - V_{in-}, positive input - V_{in+} and output - V_{out}. V_{in-} represents blue line, which is constant, since we do not change resistance of potentiometer. V_{in+} is the green line on graph and the voltage changes when we change illumination of LDR. V_{out} is the red line. We can see that it takes only two states, a logical 0 and logical 1. On graph is also clearly seen that output changes when the green line intersects with the blue one.

When using simulation time is saved and we can easily find defects in the composition of electronic circuits before actual composition on prototype board. This is the way of engineers that are involved in designing and production of new electronics products.

5. Results and conclusions

According to the experience and the response of children to summer school results, we can say that we are on the right way with working material, with instructions and with electronics kit. Methods that we use are appropriate, although there is still room for improvements. It is proven that students make good results when approached with student-centered methods. Because of that we shall continue teaching through experimenting, problem-based learning and project-orientated learning.

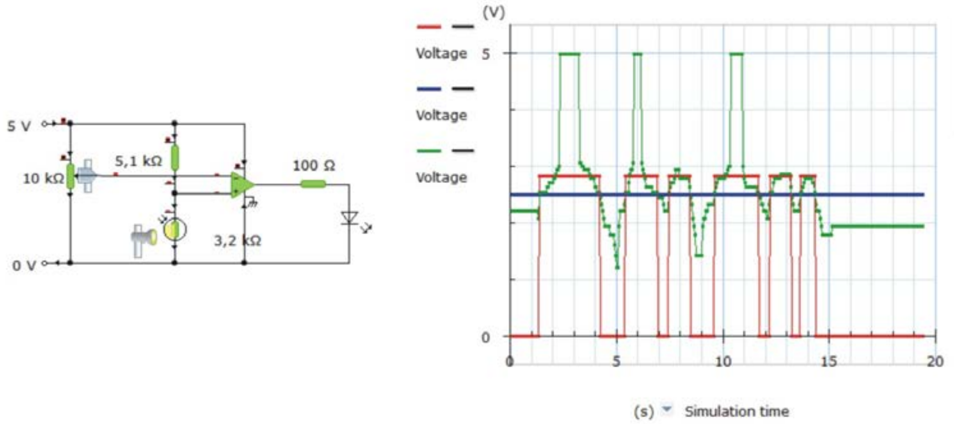

Fig. 4. Electronic circuit of light alarm with graph for analysis in Yenka

In near future we tend to improve instructions, to upgrade electronics kit and to introduce more commencing projects not only as motivation but also as experimental learning [11].

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Student work in a robotics group at summer school

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The work and learning process of students depends on the approach and manner of the teacher's work. If the teacher designs his curriculum so that they draw the students' attention to the subject matter and include them in the process itself, there's a higher possibility that the students will actually learn something and understand it. However, it's not just the knowledge that's important while learning, we must also know how to use it. In order to motivate the pupils as much as possible and actively include them in the learning process, we used the inductive approach of teaching at the robotics workshop. That means that in the foreground of this study process were the participants, who during the process acquired knowledge by inquiries and discoveries based on their proper activity. The teacher has the role of a mentor. The workshop began with guided discoveries; the participants were given smaller challenges they had to complete in groups of two. This way they learned the basics of computer programming and how to use various sensors, and they were also developing their motoric skills by constructing robots. Then they used the knowledge they acquired in a different situation, creation of their independent projects.

1. Introduction

Nowadays the teachers keep their teaching system traditional, with the deductive approach and with methods such as explanation, demonstration and discussion. That means the teachers are active and pass the knowledge to their students while the pupils are passive and absorb that knowledge, then fortify it and finally pass it back in the same form to their teachers. The alternative methods of teaching are the opposite. The students and their active cooperation during class are in the limelight. We begin the lesson with a problem or a challenge and the students feel the need for knowledge and comprehension. The pupils find new discoveries, but the important thing is the path to knowledge in which the teachers direct them.

In the robotics group at summer school, we have distanced ourselves from the usual teaching practices. We have used alternative methods such as inquiry-based learning and discovery-based learning.

2. Teaching at summer school

The deductive approach to teaching is focused on the teacher, which means in practice that they explain the subject matter and demonstrate a few examples, then the students usually practice based on the examples from the textbook. This way we do not motivate the students much because we often don't give them a reason why to learn a certain subject matter. We can achieve bigger motivation if we change our approach and use the alternative methods of teaching - inductive approach [1].

2.1. Constructivism and inductive approach

The basis of inductive teaching is constructivism, which defends empirical learning. It is important that every pupil builds his own knowledge actively and based on their thinking structures that they themselves redesign constantly. Inductive teaching includes several methods (Inquiry Learning, Problem-based Learning, Project-based Learning, Case-based teaching, Discovery Learning and Just-in-time Teaching). All methods have many common features, but mostly they are all focused on the student, require their active involvement and include them in discussions and problem solving; the teacher has the important task of directing the students through the learning process [1]. These methods are not used in practice because of the teachers' incompetence or they're time-consuming. The weakness of the methods is therefore that they demand a better and more time-demanding preparation on the teacher's part. The realization also demands more time because of the differences between students, and the teachers cannot afford to lose the already small number of hours of lessons.

In the robotics group we introduced inquiry learning and discovery learning insomuch that the pupils themselves felt the wish to learn something new, because they were then most motivated and most active. Inquiry is defined as searching for truth and knowledge. During the learning process we gave questions and challenges to the students, for which they searched answers and solutions with some guidance. The important part of this method is that the students make good questions and the teachers master the subject, easily lead them during their research and answer their questions. The students are more independent with discovery learning. They similarly are given a question or a problem for which they seek solutions, but the teachers don't lead their work. During the process the pupils acquire conceptual knowledge and later present their findings. This method was used in the second half of the robotics course where the participants designed their own project and also realized it.

2.2 Motivation

Factors of motivation are mostly appropriately chosen challenges and problems that we present to students during inductive teaching or they search for them additionally. When pupils during the teaching process acquire new findings or resolve a problem, they already gain new ideas, which motivate them even more. Differences in motivation for work can be found; students with a weaker inner motivation are less active and need more external motivation and guidance. At the summer school most participants were motivated by the physical aspect (constructing robots) and the immediate feedback for trying and discovering procedures (how a robot functions according to a written program).

2.3 Learning materials

We used a didactic inductive-based web page [2], intended explicitly for teaching robotics at the summer school. The web page includes guidance for independent work of the students in text, image and video format. At separate items there are activities, tasks and problems that the students solve by themselves, Fig. 1.

Fig. 1. Signs for student work. From left to right: the tool denotes physical activity, the notepad a task and the key a challenge or a problem.

The web page also includes links to prepared-in-advance programs written in Bascom language that the students transported to a computer and then to a controller module; this way they checked the robot's functionality and redesigned them during their lessons. That simplified the programming and helped the participants focus more on solving the challenges than the other details of the program.

According to previous experience with the robotic kits we used for this course robotic kits composed of construction bricks Fischertechnik, various electronics components (DC motor, servo motor, alpha-numeric LCD, potentiometer, an infrared distance sensor, resistors, LED) and self-developed controller module eProDas-Rob1 [3]. The particular parts are described in [4], and can be seen in Fig. 2.

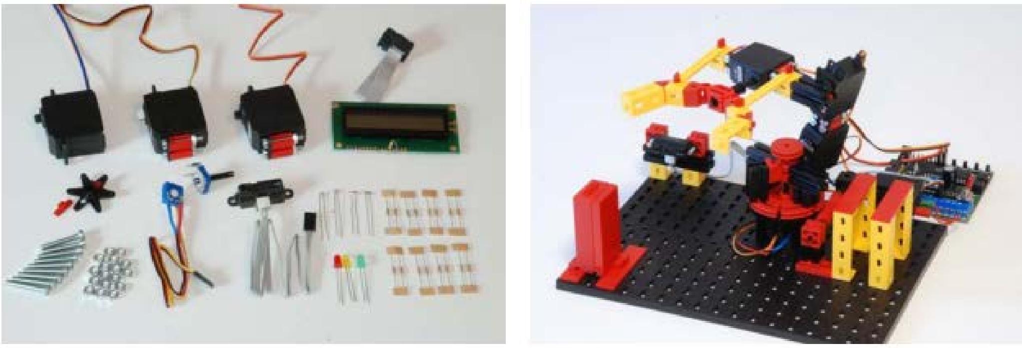

Fig. 2. Electronics components (left) and example of their unification - electronics components, self-developed controller and construction bricks Fischertechnik on a robotic hand (right) [4].

3. The activity of the participants

The group's participants worked in pairs and with a computer. Three mentors took care of ten pairs. Prior lack of knowledge of computer programming and constructional collection was not an obstacle. Pupils that have never met with this topic had no trouble with it and the others who've already had some experience were able to work faster because they've already shaped the thinking structures; here they only redesigned them. In the first three days of the summer school, with the help of a mentor and study material (a webpage) prepared in advance that helped them work on their own, they got acquainted with the Fischertechnik construction collection and the basics of programming in Bascom language. Following the instructions in the study material they put together a floodgate and a mobile robot, Fig. 3.

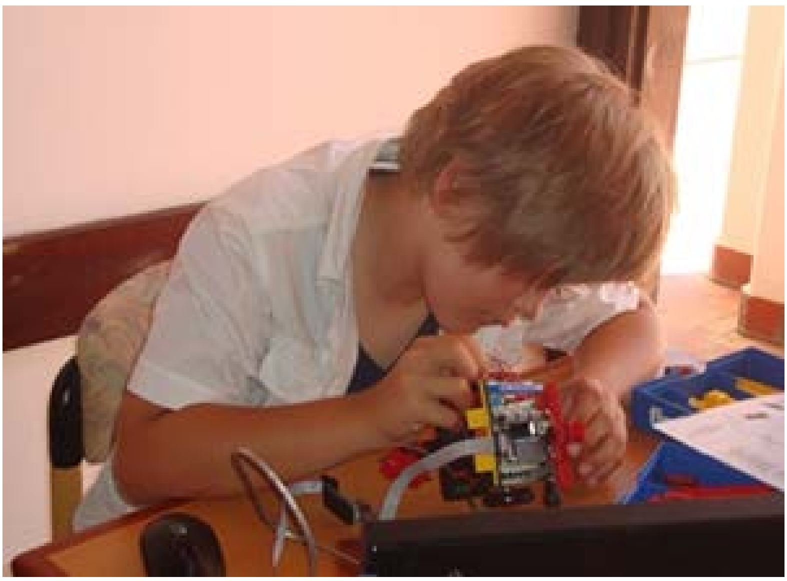

Fig. 3. Constructing a mobile robot

They gradually added and learned about digital and analogue sensors. Next to the robot construction instructions were added a challenge that they tried to solve themselves. The faster students received additional challenges from the mentor for their optimal progress. When the students faced a cognitive conflict, the mentor helped them.

After a particular degree of knowledge the pupils acquired and with the first part of robotics workshop finished, we gave instructions for the realization of the projects done in pairs. They had all previously used equipment available and additional elements from the Fischertechnik collection. They created a project based on the materials available and realized it. They used the previously acquired knowledge and were very autonomous and self-initiative. They were simultaneously investigating, testing and discovering and in this way they acquired even more knowledge. When they felt the need or wish to learn or to do something, they asked a mentor for help. The mentor didn't gave them a direct answer, but helped them use their knowledge in a new situation.

The selected teaching method was a motivating and successful one, which is shown in the fact that the participants didn't want to leave their products and take a break. The six-hour work was stopped mainly for lunch. Some participants had laptops with them and were programming even in their free time.

3.1 Independent work

The extraordinarily important competences of inductive methods are critical thinking and creativity, which were seen in the diversity of the independent projects. The participants also wrote a report on their work, in which they listed their goal for the project, the steps of realization and the used cornerstones and conclusions they have arrived at; they also added suggestions for further work. At their last day of workshop they presented their product to the other participants of the summer school.

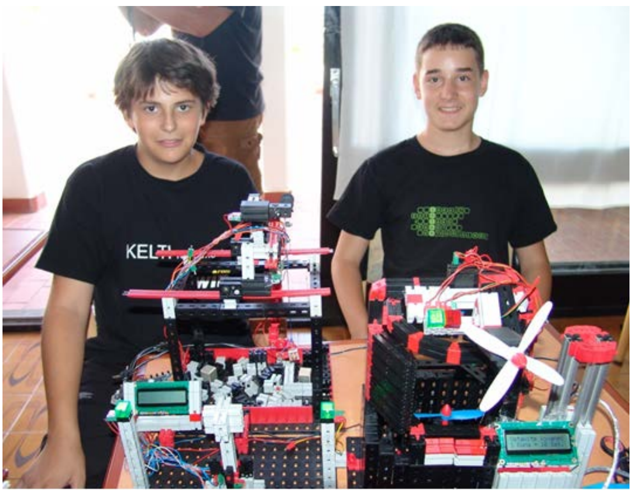

Fig. 4. An example of students that created two projects, left: cube tidying machine, right: hand dryer that functions when we insert a coin in the slot

4. Results and conclusions

The usage of the inductive method of teaching has proven to be very successful. The participants created their own projects in three days, in which they used elements and knowledge that was not acquired in the first three days but during the process of creating the project with the corresponding guidance of their mentors. The previously prepared study material (web page) was also devised appropriately and used beneficially. The participants took responsibility for their knowledge and expressed it in form of product report and the plenary presentation.

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An evaluation of INFIRO international summer school

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This paper is intended to investigate the degree of students' satisfaction with INFIRO Summer School of robotics, electronic and computerized laboratory. Research showed that predictors such as interactions, self-efficiency and self-regulations are suitable measures which contribute to student satisfaction in open learning systems. Descriptive statistics was performed to determine the contribution of predictor variables to student satisfaction. A degree of overall students' satisfaction with INFIRO Summer School is 4.6 from 5. The results also showed that learner-instructor interaction, learner-content interaction, and online and offline self-efficacy were good predictors of student satisfaction. Interactions among students and self-regulated learning have to be considered carefully. A learner-instructor and learner-content interactions are indicated as the most significant.

1. Introduction

Summer schools of Technology Education are very effective learning pathway in open learning systems [1]. Open learning (OL) refers to minimal constraints on access, pace and method of study. The term is often used to encourage traditional institutions to minimize barriers between themselves and aspiring learners. OL is very important factor to boost and develop technological literacy [2, 3], which is in domain of Technology Education (TE) curriculum. Technological literate (TL) students should be able to understand and evaluate/judge/asses technology and to help consciously and efficiently transform the natural world into the human environment. TL can be seen as technological competences complement; the ability to create, repair, and implement technologies which students learn in the context of TE [2]. Academic leaders around the world indicated that open and distance learning is critical to the long-term growth of their institutions, reporting that the increase in demand for open courses or programs is greater than that for face-to-face courses. According to previous studies, open learning does not differ considerably from traditional face-to-face classroom learning in terms of learning outcomes [4]. Student satisfaction in open learning remains undiminished when compared to face-to-face instruction [5].

Student satisfaction is an important indicator of the quality of learning experiences [4]. It is worthwhile to investigate student satisfaction in open settings because new technologies have altered the way that students interact with mentors/instructors/tutors and classmates [4, 6]. The quality of interaction in open settings may depend to a large extent on the technology tools utilized during learning [4, 7]. Lack of confidence in using information and communication technology (ICT) may decrease students' satisfaction during open instruction and in turn lower their performance. As opposed to face-to-face instruction, the nature of open learning demands greater responsibility on the part of learners [2,4]. Open learners who are unable to regulate learning efficiently are unlikely to be satisfied [8,9]. This study investigated factors (i.e., Interactions, self-efficacy, self-regulation) associated with student satisfaction in fully open learning settings.

2. Literature Review

In this part, student satisfaction and predictors of student satisfaction are investigated.

2.1 Student satisfaction

Student satisfaction can be experienced in a variety of situations and connected teaching/learning. It is a highly personal assessment that is greatly affected by student expectations. Satisfaction also is based on the student's experience of both contact with the organization and personal outcomes [10].

Evaluation is important in open education and it consists of different dimensions in alignment with the goals of a course or program. Course grades are often used as an indicator of student achievement in open instruction [4]. But affective factors can be as important as cognitive factors in explaining and predicting student learning in open settings [11]. Among the attitudinal constructs, student satisfaction, referring to student perceptions of learning experiences and perceived value of a course, may be particularly worthy of investigation. Student satisfaction is related to several outcome variables such as persistence [5], retention [4], course quality [12], and student success [13]. High satisfaction leads to lower attrition rates, higher persistence in learning, and higher motivation in pursuing additional open courses [5,10]. Education institutions consider student satisfaction as one of the major elements in determining the quality of open programs in today's markets [4]. Open learner perspectives provide valuable information on the areas that matter to students and help institutions gain a better understanding of their strengths and challenges in provision of open programs [13]. With data on student satisfaction, course designers, educators, and administrators can identify areas where improvement is needed [4,9]. Student satisfaction data can be used also students' degree choice. Furthermore, these data challenge stereotypes of the experiences of males and females in TE and have implications for how TE teaching practitioners approach the learning experience of their students.

2.2 Predictors of Student Satisfaction

Previous studies have determined factors that influence student satisfaction in open and distance learning environments [4]. The framework of this study was proposed based on the interaction model developed by [14] with the addition of potential variables including self-efficacy and self-regulated learning.

2.2.1 Interactions

Interaction has been deemed one of the most important components in open and distance education due to the computer oriented work and partially isolation of instructors and learners [12]. An interaction framework was proposed including learner-learner interaction, learner-instructor interaction, and learner-content interaction [14].

Learner-learner interaction refers to two-way reciprocal communication between or among learners who exchange information, knowledge, thoughts, or ideas regarding course content, with or without the presence of an instructor [12]. Learner-instructor interaction consists of two-way communication between the instructor of a course and learners. Learner-content interaction is a process of individual learners elaborating and reflecting on the subject matter or the course content. In contrast with learner-instructor and learner-learner interaction, only one person – the learner – is directly involved in learner-content interaction [12]. At OL, new types of interactions were found, namely: instructor-instructor, instructor-content, and content-content interaction [4].

Previous research has indicated the positive influence of interaction on student satisfaction in open and distance education [4]. Of the three types of interaction, learner-learner interaction and learner-instructor interaction were investigated more often than learner-content interaction. Learner-learner interaction and learner-instructor interaction seem to be more related to and predictive of student satisfaction than learner-content interaction in most studies of open learning [4]. Learner-instructor interaction was the most required interaction in his summary from several open studies [15]. However, the findings are inconclusive. Some studies indicated that the amount of interaction that learners have with the content is the most important to student satisfaction in computerized laboratory based learning, in comparison with learner-learner interaction and learner-instructor interaction [4].

2.2.2 Self efficacy

Expanded from the self-efficacy theory in psychology [16], researchers in education have indicated that efficacy beliefs positively influence achievement and persistence related to specific instructional tasks [17]. Online and offline self-efficacy (ONOFSE) refers to the belief in one's capability to organize and execute computer-related actions required to accomplish assigned tasks [4]. There are two reasons to include ONOFSE as a predictor of OL student satisfaction. First, OL relies on ONOFSE delivery through which various types of activities take place such as computer design and implementation, measurements, collaborative projects, communication with instructor or classmates, and so on [4,9]. Technical problems while using the computer, computer based devices, and equipment may cause student frustration and dissatisfaction [4,10]. It seems important for OL learners to possess high ONOFSE to complete required tasks for an open course delivered through the computerized laboratory.

Secondly, ONOFSE, as one of the three self-efficacy constructs in computer-based instruction, is less addressed than academic self-efficacy or computer self-efficacy. The impact of ONOFSE on student satisfaction is scarce and inconclusive (High School, University) while for Primary School students is significant. ONOFSE is positively correlated with expected outcomes including entertainment, social, and informational outcomes what is indicated in [4].

2.2.3 Self-regulated learning

Self-regulation, originally from psychology, was first defined by [18]. The central ideas underlying self-regulation are motivation and learning strategies that students utilize to achieve their learning goals. The scope of self-regulation has been expanded to studies in education areas [4,9]. Self-regulated learning refers to the degree to which students metacognitively, motivationally, and behaviorally participate in their own learning [19]. Metacognitive processes involve learners' ability to plan, schedule, and evaluate their learning progress. Motivational processes indicate that learners are self-motivated and willing to take responsibility for their successes or failures. Behavior refers to the characteristics of the strategies that students utilize to optimize learning [19]. The importance of self-regulation in student performance is evident in traditional face to- face learning settings [19] and Blended Learning settings [10]. Unlike traditional classroom instruction, open learning is student-centered and much self-directed effort is required for success [20]. Although most of the studies have indicated that the ability to self-monitor and self-evaluate at different learning stages is positively related to student performance or achievement, there is very limited research pertaining to the association between self-regulation and student satisfaction. The motivational components of self-regulation are positively related to student satisfaction [20]. Meta-cognitive self-regulation is positively correlated with student satisfaction at a significant level is indicated by [8]. This study also focuses on metacognitive self-regulation because metacognitive processes are considered to be the most critical in self-regulation [19,20].

3. Method

Sample, Instrumentation, and Procedure and Data Analysis of our study are described in the following text.

3.1 Sample

The sample of this study consisted of Secondary School students enrolled in summer-session open courses of INFIRO Summer Schools. First INFIRO Summer School 2012 was held in June 2012, 7-23 and the second one was held in June 2013, 23-29. The venue of INFIRO Summer School is Rabac, Croatia. The summer-session courses were 1 week long. With the permission of and assistance from the parents and instructors who agreed to have their students participate in the study, a paper and pencil survey was distributed. All of the enrolled students completed the survey. There were more male respondents than females (Table 1). Most respondents were between the ages of 14 and 16 years. There were only a few students less than 14 and over 16 years old. In INFIRO Summer school 2012, just two INFIRO project countries had recruited the participants, namely Croatia and Slovenia. In the second INFIRO Summer School, 2013, all INFIRO project countries (Croatia, Slovenia, Turkey, and Romania) have been involved in open learning, most participants came from Croatia and Slovenia.

Table1. Participants of the INFIRO Summer School 2012 and 2013

Participants	2012 Frequency [/]	2013 Frequency [/]
Total	44	61
Male	36	52
Female	8	9

3.2 Instrumentation

The survey included 15 questions on three predictor variables, and student satisfaction. Instrument development was involved for interaction and student satisfaction scales. Overall student satisfaction is 5-point Likert Scale with 4 items that ranged from 1 (*very unlikely*) to 5 (*very likely*). Questions on the ONOFSE were developed to measure one's confidence in the ability to be successful in performing certain tasks using computer-based technology. The self-regulated learning scale was adopted from the metacognitive self-regulation subscale in the Motivated Strategies for Learning Questionnaire (MSLQ) . The scale is a 3-point Likert scale with 4 items ranging from 1 (*not at all true of me*) to 7 (*very true of me*). It assesses the extent to which learners used planning, monitoring, and regulating strategies during the learning process. Beside this, also open ended questions about judgment, expectations, decision making, behavior and affective part are included.

3.3 Procedure and Data Analysis

The survey was administered, use of paper and pencil method when INFIRO Summer School has ended. High response rate was obtained by direct presence of mentors and survey administration. Data analysis was conducted using Excel. Descriptive analyses were conducted to present the student basic information and the average score of predictor sub-variables and student satisfaction.

4. Results

An evaluation of the INFIRO Summer School (ISS) is grounded on the evaluation of the ex-post questionnaire, which was administered to students, on site, paper and pencil method.
Fig. 1. illustrates average scores of students' satisfaction with INFIRO Summer School (ISS). Satisfaction scale is divided into four subscales at range 1-5. Participants of the ISS are most satisfied with work and approaches of mentors and tutors, the weakest point is accommodation and meals where most complaints go to the meals. An improvement is done at physical learning environment. Overall rank is very good to excellent.

Students also expressed their emotional/perception impressions and opinions (Fig. 2). At ISS 2012, students were most impressed with final project implementation and evaluation (32 %) and venue of ISS (23 %). Workshops and method of open learning is recorded at 14 % valuable. While, at ISS 2013, students have gained/developed social components (25 %) and were impressed by the successful final projects' operation/implementation and evaluation (18 %).

Participants of the ISS 2012 had estimated the mentors (work, approach, willingness to help...) as the most valuable part (71 %), also organization of the ISS is commended a lot (20 %). The same is indicated also for ISS 2013. This depicts strong mentor-learner interactions (Fig.3).

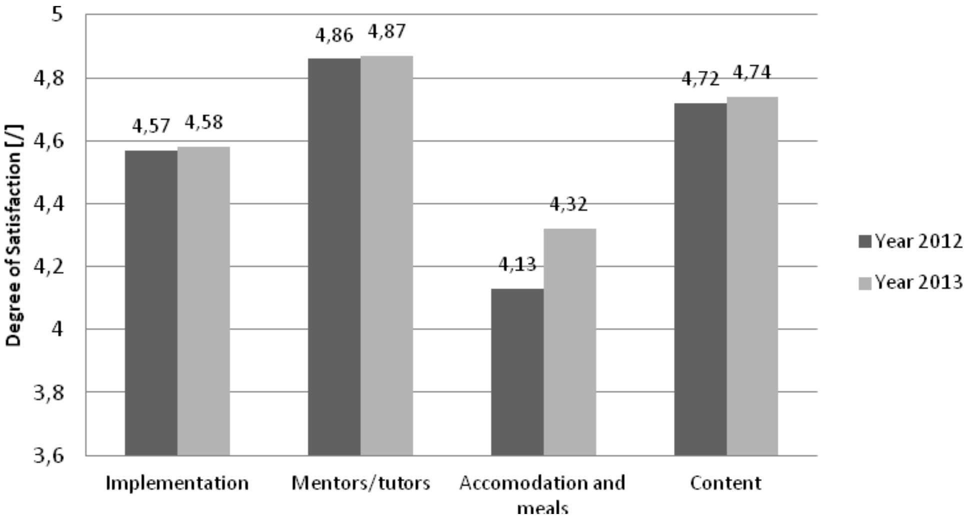


Fig.1. Overall students' satisfaction

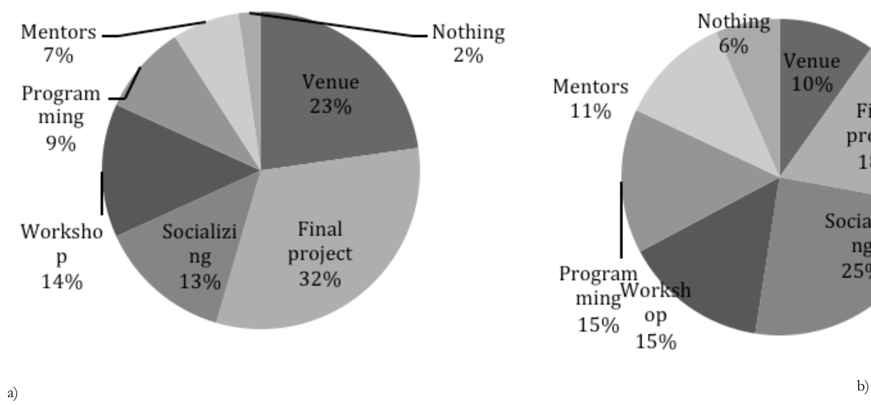
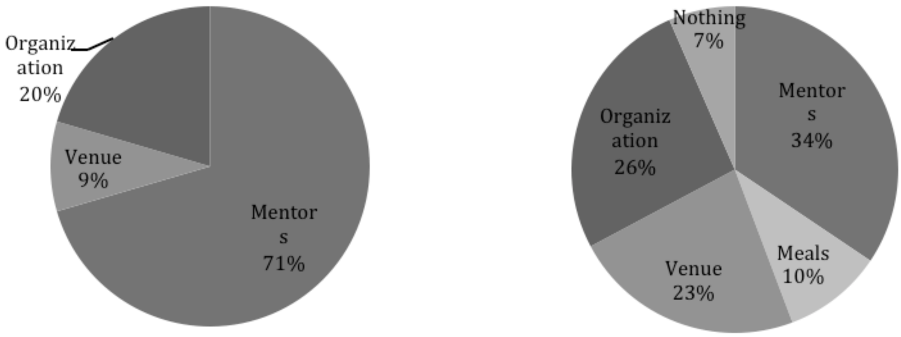


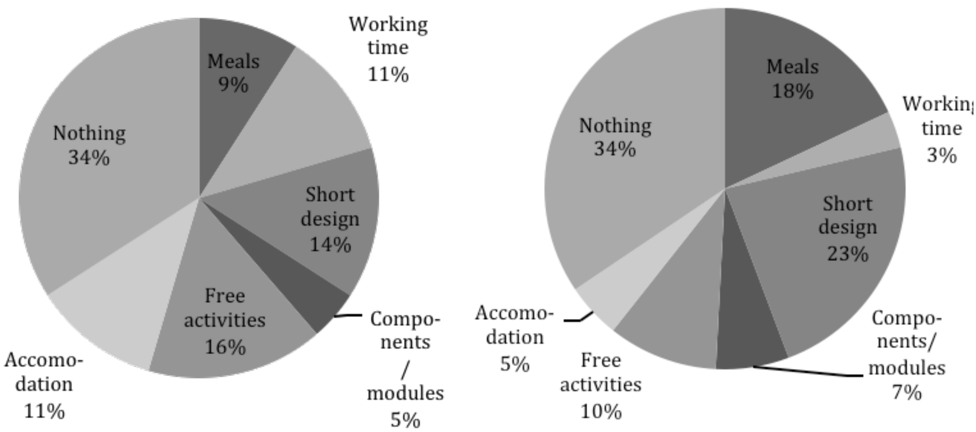
Fig.2. Students first impressions in a) ISS 2012, b) ISS 2013



a) b)

Fig.3. Most positive-desirable attitude in a) ISS 2012, b) ISS 2013

Most participants are satisfied with ISS 2012 (34 %), remarkable 16 % of participants have complained on free social activities. A part of participants wanted to work and to learn more. A lack of rotation of the groups where everyone can be assigned with electronics and robotics as well (14 %) is detected. An extension of working time is suggested. Also problems exist with the meals (9 %). Working time is not suitable for 11 % of attendees. They suggest postponing start of workshops for 1 hour and in the evening; it uses to be prolonged of 2 hours. During the hottest period of the day, it must be not so work active time. Students have also complained about working place and air-condition, which was not proper (11 %). They have estimated (Fig.3) a lack of modules and components for effective work (5 %).

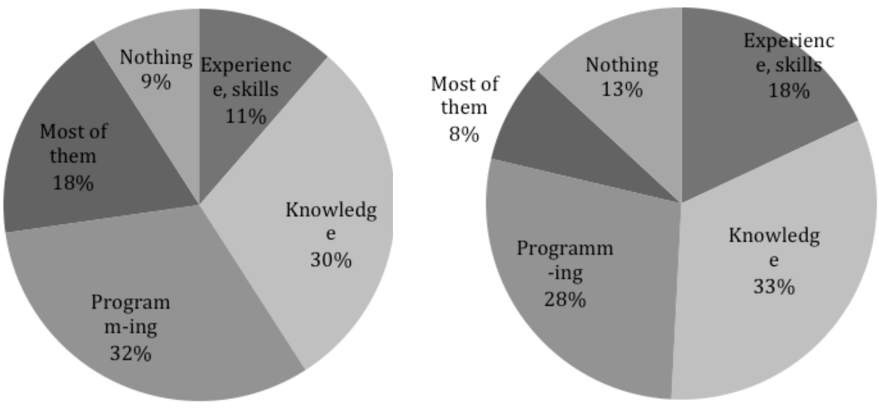


a) b)

Fig.4. Most negative-undesirable attitude in a) ISS 2012, b) ISS 2013

Most participants are satisfied with all (34 %); remarkable 23 % belongs to short design of the ISS 2013. A part of participants wanted to work and to learn more. Also they missed a rotation of the groups where everyone can be assigned with electronics and robotics as well. An extension of working time is suggested. Also problems exist with the meals, but it is better than previous year overall score.

Willingness/readiness to participate on next ISS is indicated in ISS 2012. Majority of the students (93 %) want to attend at the ISS 2013, just 5 % are not willing to do, while 2 % are undefined. The situation at ISS 2013 is similar.
Needs fulfillment in ISS 2012 is remarkable. Most, 52 % of the students are satisfied with all what they expected (level 3), while 46 % of the students are also satisfied in majority what they expected before (level 2). Just 2 % of the attendees are partly fulfilled (level 1). For the ISS 2013 is similar. Most, 51 % of the students are satisfied with all what they expected, while 46 % of the students are also satisfied in majority what they expected. Just 3 % of them are partly fulfilled.
Complexity/difficulty of the ISS 2012. Just 4 % of the students marked as complex (level 3), while majority (89 %) of the attendees assessed ISS as medium difficulty (level 2). For the ISS 2013, 12 % of the students indicate as complex, while majority (72 %) of the attendees had assessed ISS as medium difficulty.
Entertainment and social part of the ISS. At ISS 2012 majority (80 %) of the attendees of the ISS confirm an entertainment component as medium (level 2). Just 2 % of participants argue that entertainment was not enough engaged here (level 1). For the ISS 2013, majority (79 %) of the attendees of the ISS confirm an entertainment component as moderate (level 2). Just 6 % of participants argue that entertainment was not enough engaged here.
Availability of free time/activities. At ISS 2012, 75 % of attendees had estimated just right share of free time versus working time, while 18 % confirmed a lack of free time. At ISS 2013, 61 % of attendees have assessed just right share of free time versus working time, while 23 % detected a lack of free time.
Transferable deliverables of the ISS (Fig.5). At ISS 2012, Programming knowledge and skills (32 %) will be very useful for further study. This is estimated surprisingly very high and this behavior is more typical for summer school of computing. Participants argue that professional knowledge of electronics and robotics (30 %) will be transferable for future study and work. Also, 11 % of attendees estimate gained workshop skills and experience as positive result for future work. All deliverables will be used for 18 % of attendees. **At ISS 2013**, participants argue that professional knowledge of electronics and robotics (33 %), and programming knowledge and skills (28 %) will be very useful for further study. Also, 18 % of attendees estimate gained workshop skills and experience as positive result for future work.

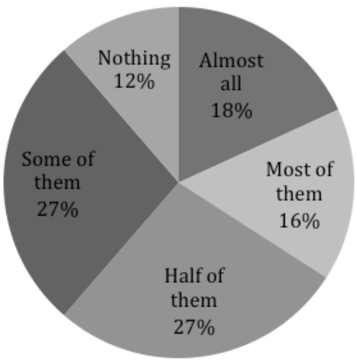


a) b)

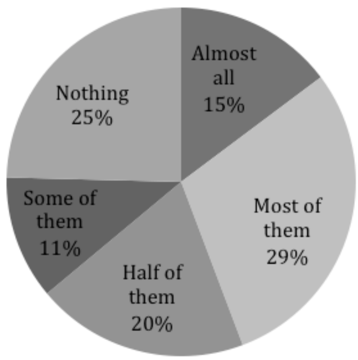
Fig.5. Transferable deliverables in a) ISS 2012, b) ISS 2013

Possible novelties in ISS (measuring electric current, voltage comparator, soldering, R-S flip-flop, Bascom, voltage measuring, a-stable multi-vibrator, transistor usage, electric circuits simulation software, team/pair work).
Fig. 6 illustrates pre-acquaintance with the ISS features. In ISS 2012, there are 1/3 of students which are not so common with the ISS professional features/content. This group of students was insufficient assigned with electronics and robotics in Secondary School. Just 12 % of attendees are very natives with ISS, while 18 % present a group of beginners for the ISS design. The rest of attendees are already acquainted with some of them to half of ISS features (54 %). They were assigned with electronics and robotics at optional subjects in Secondary School and this information was useful for workshop group design to improve efficiency of the workshops. We can conclude that a good target group was established for piloting first ISS 2012. Attendees from Croatia and Slovenia have possessed at least basic to medium knowledge of electronics and robotics, with some advanced exceptions.

In ISS 2013, there are two remarkable groups of students. The first one of 25 % is already acquainted with all of ISS professional features/content. This group of students was already assigned with electronics and robotics at optional subjects in Secondary School and this information was useful for workshop group design to improve efficiency of workshops. The second group of 29 % of participants where majority of listed features present novelties. Some students (15 %) are very beginners in ISS, as it is designed for the INFIRO purpose. We can conclude that a good balance of the learning and training content existed.



a)



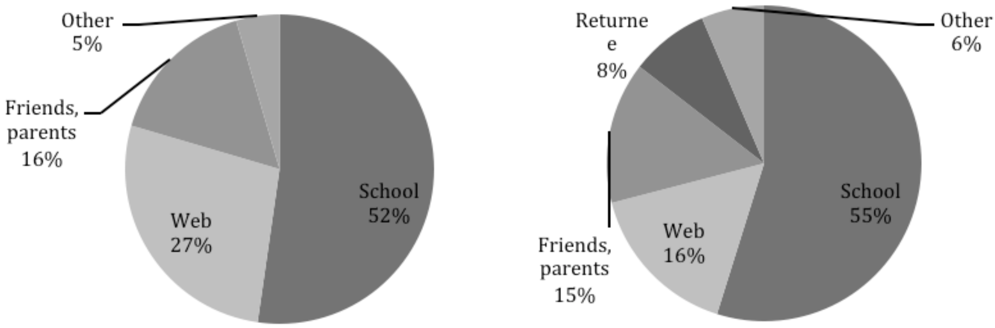
b)

Fig. 6. Pre-acquaintance with ISS professional features/content in a) ISS 2012, b) ISS 2013

Organization of the social/sports activities in ISS. In ISS 2012 (89 % satisfied students) had organized social-sports activities remarkably. Especially a visit to the Adrenalin Park, and region sights have fulfilled majority of attendees' expectations. In ISS 2013 (62 % satisfied students) had less organized social-sports activities than ISS 2012 (89 % satisfied participants). Students have mentioned a lack of organization of these sorts of activities, possible guided tour at regions sights/attractions or visit to adrenalin park as it was in ISS 2012. A lack of social games was recorded.
Uniforms (T-shirts) for participants. In ISS 2012 majority of participants (91 %) was very satisfied with T-shirts got. Just 9 % were recorded as not proper, because of color and signs. In

ISS 2013, majority of participants (69 %) was satisfied with T-shirts got. 13 % of students were not satisfied at all, while the rest of them preferred different colors as blue, red, purple, and a pink one for the girls. Also they've missed larger symbols/logos on the uniforms.

Information channel/path. In ISS 2012, the most of the participants (52 %) were informed about in School (teachers, pedagogues etc.). Also web information about ISS was available via national Technology and Engineering Associations (27 %) and some of them (16 %) were informed by friends and parents. In ISS 2013, the most of the ISS participants (55 %) were informed about in School (teachers, pedagogues etc.). Also web information about ISS was available via national Technology and Engineering Associations (16 %) and some of them (15 %) were informed by friends and parents (Fig.7).



a) b)

Fig.7. Information channel in a) ISS 2012, b) ISS 2013

Decision-making factors for the ISS attendance. In ISS 2012, most participants were very interested for the ISS, because of personal interest (48 %) and ISS content (16 %). Parents and friends have influenced at 18 % as well as other factors such are, the previous experience with similar summer schools, venue etc. In ISS 2013, the content of the ISS and personnel interest had attracted almost 2/3 of participants to take part at ISS. Venue of the ISS (10 %) was also decisive as well as other factors such are parents influence, the previous experience with ISS or similar, friends etc (Fig.8).

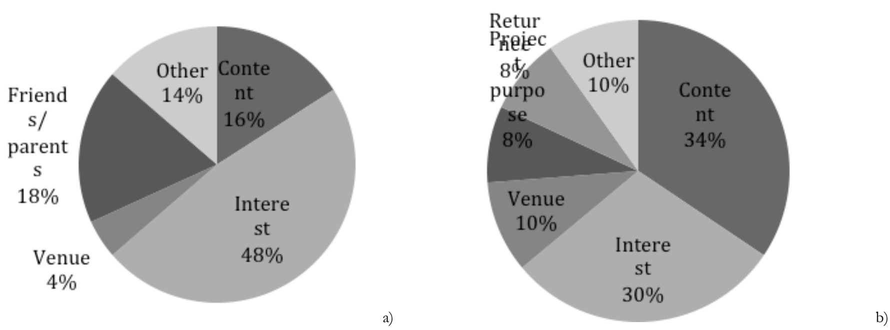


Fig.8. ISS decision making factors in a) ISS 2012, b) ISS 2013

5. Conclusions

The purpose of this study was to investigate student satisfaction with INFIRO Summer School as a measure of lesson-course and learning quality. We found that students overall satisfaction is high, 4.6 from 5. This indicates very good to excellent INFIRO Summer School design and implementation. Investigation was also oriented on student satisfaction predictors where significant and valid confirmation was found. Learner-instructor interaction, learner-content interaction, and online-offline self-efficacy were significant predictors of student satisfaction in fully open learning settings, while learner-learner interaction and self-regulated learning did not predict significantly student satisfaction. Learner-instructor interaction was the strongest predictor among those significant predictors of student satisfaction. The importance of the interactions in open learning was confirmed.

The practical implications of this study are that both instructors and course designers should pay attention to content design and organization given that learner-instructor interaction substantially contributes to student satisfaction. Instructors should pay attention to students and provide feedback to students in a timely fashion or encourage students to ask questions through different mechanisms. Implementing a technology training orientation before open courses start may help increase students' confidence in performing online-offline-related tasks required by the course and in turn enhance student satisfaction. Gender seems to be good indicator of the amount of interaction among learners. Instructors are encouraged to design more collaborative activities in Primary and Secondary School courses to enhance learner-learner interaction. Time spent online/offline may inform instructors about students' online-offline self-efficacy and self-regulation level.

Further research is required to replicate these findings amongst the other samples/target groups, and to identify whether there are specific variations in teaching practices that are particularly salient to the satisfaction of female students. Furthermore, future research should also explore the possibility that these results could be explained by gender differences.

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Arduino UNO R3 a microcontroller circuit board

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If we are looking for easy to learn, efficient microcontroller board that can be programmed in C programming language one of widely accepted solution is Arduino Uno. This board can be used for constructing a large variety of robots, sensing devices or any other type of mechatronic devices. In this article we present Arduino board, hardware expansions of this board, which we usually call "a shield", and development environment (Arduino IDE), which is used for writing and transmitting programs "sketches" to the microcontroller.

1. Introduction

Microcontroller is an integrated circuit in which in the addition of processors and memory there are additional circuits which allow it to connect with other elements and assemblies for example-button switches, transistors, gauges, relays, etc. It can be considered as a small computer for specific applications. The microcontroller can communicate with a personal computer, mobile phone, a robot and with similar devices. It is supplied from a DC voltage source, thereby commonly used values of voltage up to 5V. Availability of microcontrollers and a relatively low price makes them suitable to be used in a wide variety of areas.

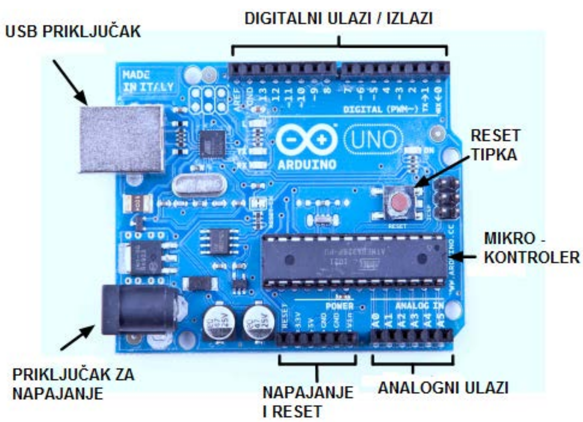

Fig. 1. Arduino microcontroller board

Arduino UNO R3 is a microcontroller circuit board with 14 digital inputs or outputs and 6 analogue inputs. Digital ports are numbered from 0 to 13.When used, as they exit, allow setting voltage levels on 0 or 5V, or logical states, 0 or 1.Also through them it is possible to read out the logical state. Embedded microcontroller ATmega328 is based on 8-bit RISC architecture and has a 32KB reprogrammable print FLASH memory.

Analogue connectors labelled with A0 to A5 allow connection of any amount of voltage in the range of 0 to 5V. Some sensors, such as temperature transducers, can make these voltage values. If they are not used as analogue, these ports can serve as digital inputs or outputs. It should be noted that the maximum output current of each port is 40 mA at 5V voltage when all the connections on port are not in use. We have worked with resistors whose resistance value was greater than 200 ohms to limit the current flow through each port.

Connections on the tile marked with TX and RX are used as output and input data for serial communication, while "~" in some ports (3, 5, 6,9,10 and 11) means that they can be used for pulse-width modulation (PWM).

The board itself is powered via the USB port, but if you use higher power loads such as motor we use on small mobile robots, it is necessary to bring an external power from a DC source in the range of 7.5 to 12 V via the power connector (the DC power jack). There is a third possibility to power the board and it is by using the port (PIN) "Vin" which is located on the board itself. Connections 5V and 3.3V are outputs of stabilized voltage, and can be used to supply additional modules and assemblies. Transmission of executable code from PC to the Arduino can also be made via the USB port, and during the execution of a program it is possible to communicate with a personal computer in terms of reception and transmission of data and commands.

2. Shields

Simple design of extension connectors gives the possibility to add various additional modules (shields).

Fig. 2. An example of an upgrade (shield) of Arduino board

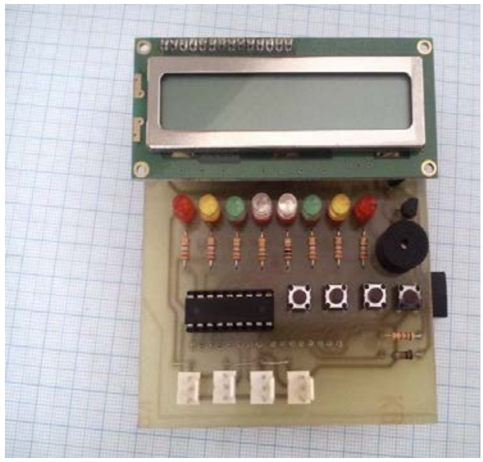

Fig. 3. LCD and LED expansion module created as DIY

Boards for an upgrade or modules are specifically designed for easy expansion by inserting above the existing board. In this way, we can customize hardware as needed, for example to add a LCD or LED indicators, keypad, relays, etc.. These boards can be made as DIY.

3. TinkerKit

Tinkerkit is a set of modules used for easier and faster performance of Arduino applications and testing of the program. Because of its simple application TinkerKit kit is suitable for learning.

It consists of an expansion plate (shield), of various modules (LEDs, pushbuttons, sensors...) and cords of various lengths. Using cables with three-pin connectors that prevent polarity inversion carries out connecting modules with the expansion plate. When connecting to higher power loads (eg. motors) it is necessary to pay attention not to exceed the maximum permissible current load of USB 2.0 port, which is 500 mA.

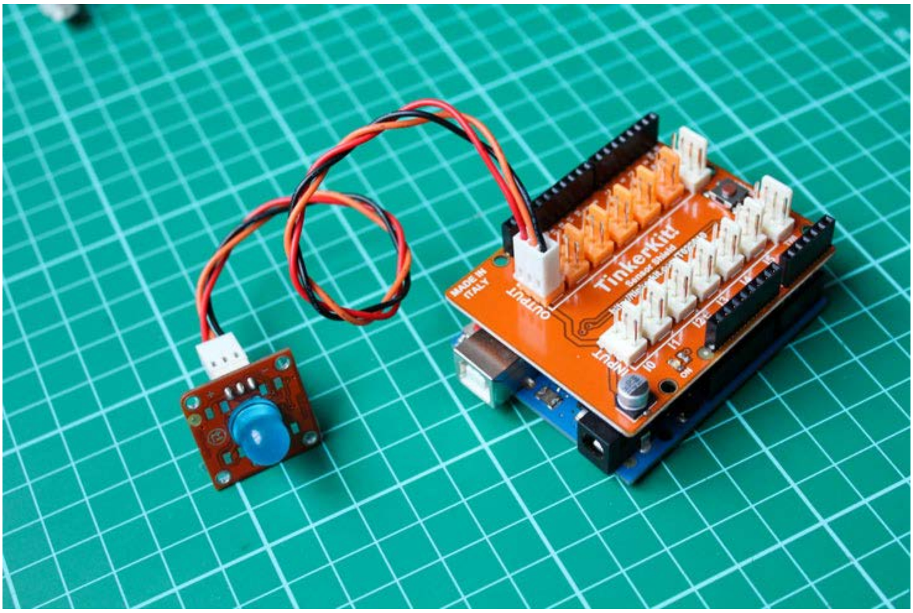

Fig. 4. An upgrade of Arduino with Tinkerkit module and LEDs

4. Programming of microcontrollers

We know that the processor is a machine executor or series of commands. The program must therefore be stored in the program memory (Flash ROM) in binary form, which is part of an integrated circuit microcontroller. In addition to program memory there is a small amount of data memory (RAM), which temporarily stores data. Unlike FLASH ROM that retains the content after switching off the power supply, the data in RAM are deleted. The task of the software programmer is to write a program that will be permanently recorded in the memory of the microcontroller, and then it will execute independently of the PC on which the source code of the program was written.

The actual making of the program therefore is done on a personal computer in a way that we write commands via keyboard. After we create the program, it is converted to a form of power, which consists of the binary values (1 or 0), and then sent via the USB cable to the Arduino. To do this we need to have development environment (Arduino IDE) installed on our PC. The source form of the program that is written in this development environment has the name "sketch".

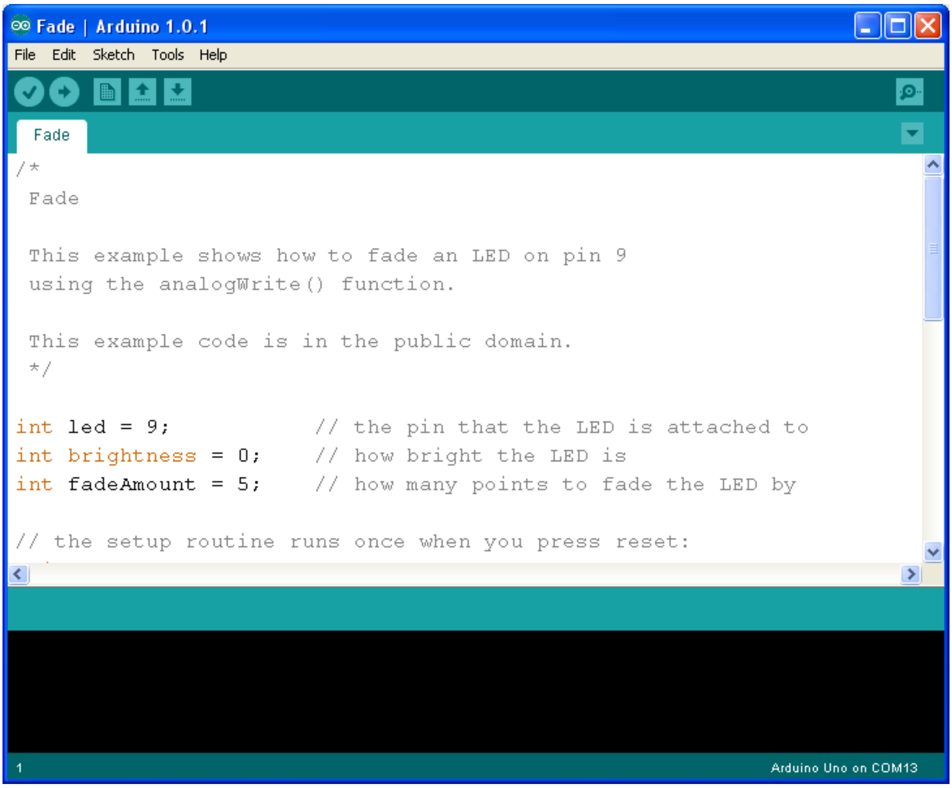

Fig. 5. The appearance of Arduino development environment

Creating a new program can begin by selecting "File" and then "new" or with the button on the toolbar.

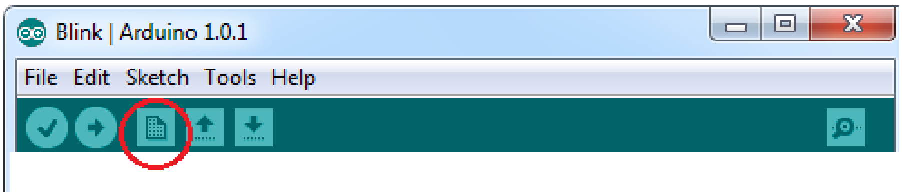

Fig. 6. Creating a new program within the development environment

Arduino C is a programming language based on the syntax of C programming language and most of the commands are identical or similar except for those related to specific microcontroller hardware.

Writing of the source code begins with the declaration of variables. The variable is actually a part of memory which holds some information, and in the course of executing a program this information in this place may change. Any such place is named, so later we could have access. Besides the name, the variable has a type and a value.

Example of variable declarations:

int speed = 0; *// Declare a variable "speed"*

Here "int" is a type of a variable, "speed" is the name, and zero is the default value. By the sign ";" we end the declaration of a variable or command, and the text after two slashes is the comment command.

Data types are similar as in the C language.

Table 1: Types of data

Type of variable	Interval
boolean	True or False (1 or 0)
byte	0-255
char	from -128 to 127
unsigned char	0-255
int	-32,768 to 32 767
unsigned int	0-65535
word	0-65535
Long	-2147483648 to 2147483647
unsigned long	0-4294967295
float-3.4028235E	of +38 3.4028235E +38 to
double	the- 3.4028235E +38 to 3.4028235E +38
string	string of signs
array	string of variables

In addition to variables, it is possible to declare constants.

Example of declaration of constants:

const int acceleration = 2; *// Declaration of a constant "acceleration"*

During the execution of a program constant value does not change.
Every Arduino program or "sketch" should have at least two parts: a "setup" and "loop". "Setup" is a routine that is executed only once when starting the program and here it is usually determined which port will serve as an input and which as output (initialization). The main program is executed in the "loop" and continually repeated. So when it comes to the last command, it is followed by the first, then second, and so on.
After the program is written it is necessary to verify the accuracy or syntactical errors. We do this by selecting "sketch" and then "Verify / Compile" or via a button on the toolbar. If there are no syntax errors at the same time a machine code is made.

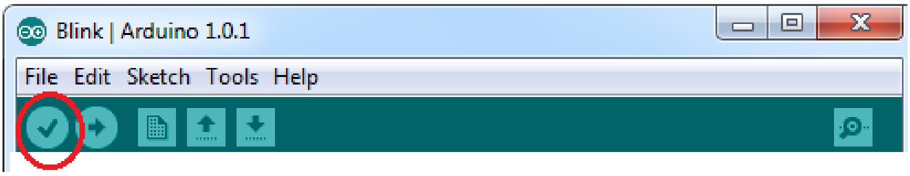

Fig. 7. Transfer within the development environment

In order to transfer the machine code to the Arduino tile, it must be connected via USB cable to a PC. We use the button on the toolbar to initiate the process of programming the microcontroller's memory.

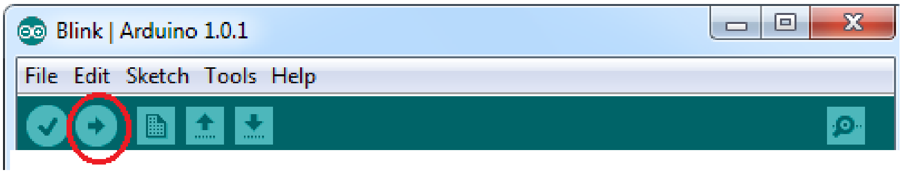

Fig. 8. Transfer of the executive program code within the development environment

Once the machine program is written on the microcontroller's FLASH ROM, it is permanent and is performed independently without a PC.

6. Results and conclusions

After testing this hardware and software solutions in our school we had to conclude that they are very good for teaching purposes. Summary of these testing activities is described in several exercises presented in this conference as separate documents. . For further reading teachers and student could refer to other books published about robotics [1] or about Arduino [2].

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Arduino: an open electronics prototyping platform

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Arduino is a platform for prototyping interactive objects using electronics. It consists of both hardware and software: a circuit board that can be purchased at low cost or assembled from freely-available plans; and an open-source development environment and library for writing code to control the board. Arduino comes from a philosophy of learning by doing and strives to make it easy to work directly with the medium of interactivity. It extends the principles of open source to the realm of hardware, supporting a community of people working with and extending the platform. It has been used in universities around the world and in numerous works of interactive art.

1. Introduction

Arduino allows users to create working electronic prototypes, either stand-alone objects or devices tethered to a computer. It can read from a wide range of sensors, control a broad spectrum of output devices, and communicate with software running on a computer or talking over a network. There are many steps required to perform the most basic of tasks with a microcontroller: picking a particular microcontroller, figuring out the circuit needed to use it, ordering the necessary parts, assembling them, downloading the software needed to program the microcontroller, figuring out a way for the microcontroller to talk the computer, installing any necessary drivers, buying or building an external device to program the microcontroller, learning how to write code for the microcontroller (which may require reading a datasheet that is hundreds of pages long), writing the code, working out the command line arguments needed to compile and upload the code, etc. Arduino attempts to eliminate or ease as many of the steps as possible with a combination of hardware and software.

2.1. Hardware

An Arduino board consists of an Atmel 8-bit AVR microcontroller with complementary components to facilitate programming and incorporation into other circuits [1]. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus, allowing many shields to be stacked and used in parallel. Official Arduinos have used the megaAVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. A handful of other processors have been used by Arduino compatibles. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator (or ceramic resonator in some variants), although some designs such as the LilyPad run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions [3]. An Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer.

At a conceptual level, when using the Arduino software stack, all boards are programmed over an RS-232 serial connection, but the way this is implemented varies by hardware version. Serial Arduino boards contain a level shifter circuit to convert between RS-232-level and TTL-level signals. Current Arduino boards are programmed via USB, implemented using USB-to-serial adapter chips such as the FTDI FT232. Some variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. (When used with traditional microcontroller tools instead of the Arduino IDE, standard AVR ISP programming is used.)

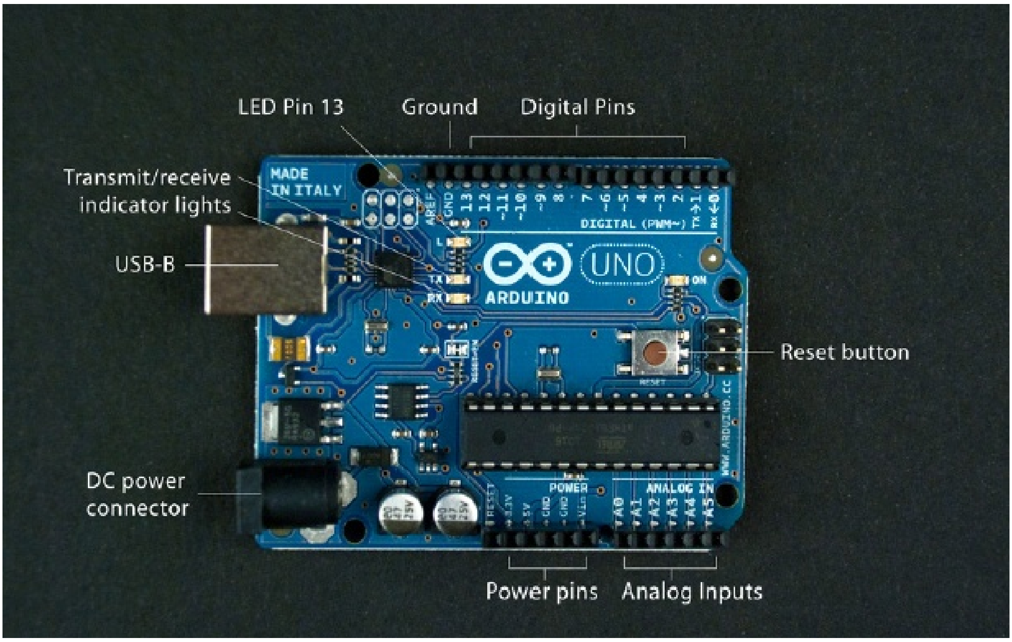


Fig. 1. A serial Arduino board with removable Atmega328 microcontroller, one of the original versions of the Arduino hardware.

14 Digital IO pins (pins 0–13)
These can be inputs or outputs, which is specified by the sketch you create in the IDE.
6 Analogue In pins (pins 0–5)
These dedicated analogue input pins take analogue values (i.e., voltage readings from a sensor) and convert them into a number between 0 and 1023.
6 Analogue Out pins (pins 3, 5, 6, 9, 10, and 11)
These are actually six of the digital pins that can be reprogrammed for analogue output using the sketch you create in the IDE.
The board can be powered from your computer's USB port or an AC adapter (9 volts recommended, 2.1mm barrel tip, centre positive). If there is no power supply plugged into the power socket, the power will come from the USB board, but as soon as you plug a power supply, the board will automatically use it. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board to be plugged into solderless breadboards.

2.2 Software

The Arduino software is an attempt to simplify the process of writing code without unduly limiting the user's flexibility. It builds on many other open-source projects, adapting them to the Arduino hardware and hiding their unneeded complexities [2]. The Arduino software consists of two main parts: the development environment and a core library, both are open-source. The

Arduino development environment is a minimal but complete source code editor. It is a cross-platform application written in Java and usable under Windows, Mac OS X, and Linux. In it, users can manage, edit, compile, and upload their programs (called sketches). All functions can be accessed from a set of seven toolbar buttons or a few drop-down menus. The user need not fiddle with make files or command line arguments, which can pose significant obstacles for the beginner. The environment includes a serial monitor, allowing the user to send data to and receive data from the board, easing debugging without requiring additional software. In fact, all programs required for Arduino development are included in a single archive that can be downloaded from the Arduino website. The GUI itself is based on the Processing development environment, while sketches are compiled by avr-gcc. The source code is distributed under the GNU Public License (GPL).

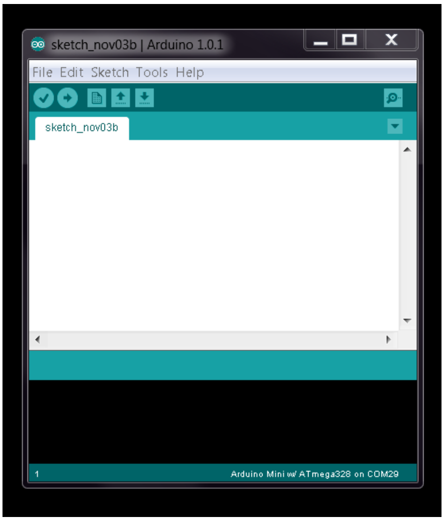
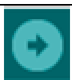
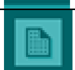
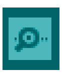


Fig. 2. The Arduino environment

Table 1. Arduino Environment Toolbar Buttons

	Compile: This button is used to check the “syntax” or correctness of your code. If you have anything labeled incorrectly or any variables that were not defined, you will see an error code in red letters at the bottom of the IDE screen. If, however, your code is correct, you will see the message “Done Compiling” along with the size of your sketch in kilo-bytes.
	Stop: If you are running a program that is communicating with your computer, pressing this button will stop the program.
	New: This button clears the screen and enables you to begin working on a blank page.
	Open: This button lets you open an existing sketch from file. You will use this when you need to open a file that you have downloaded or have previously worked on.
	Save: Select this button to save your current work.
	Serial Monitor: Allowing the user to send data to and receive data from the board.

The Arduino core library consists of AVR C/C++ functions that are compiled along with the user's sketch. The combined binary file can then be uploaded to the Arduino board. Using an API compatible with Wiring, the Arduino core encapsulates low-level aspects of microcontroller programming (e.g. register manipulation), allowing users to concentrate on their particular task. In particular, this saves users from having to read the 300- page data-sheet for the microcontroller, the only reliable source for information on its low-level functionality. Users are still programming in standard C/C++, however, so the programming knowledge they acquire can be transferred to many other situations. In fact, the full source code to the Arduino core (licensed under the LGPL) is included in the distribution, so that curious users can learn how it works and modify it.

3. Sample Arduino Code

In most programming languages, the first program is "hello world". Since an Arduino board doesn't have a screen, we blink an LED instead. The boards are designed to make it easy to blink an LED using digital pin 13. Some (like the Diecimila and LilyPad) have the LED built-in to the board. On most others (like the Mini and BT), there is a 1 Kohm resistor on the pin, allowing you to connect an LED directly. (To connect an LED to another digital pin, you should use an external resistor). LEDs have polarity, which means they will only light up if you orient the legs properly. The long leg is typically positive, and should connect to pin 13. The short leg connects to GND; the bulb of the LED will also typically have a flat edge on this side. If the LED doesn't light up, trying reversing the legs (you won't hurt the LED if you plug it in backwards for a short period of time).

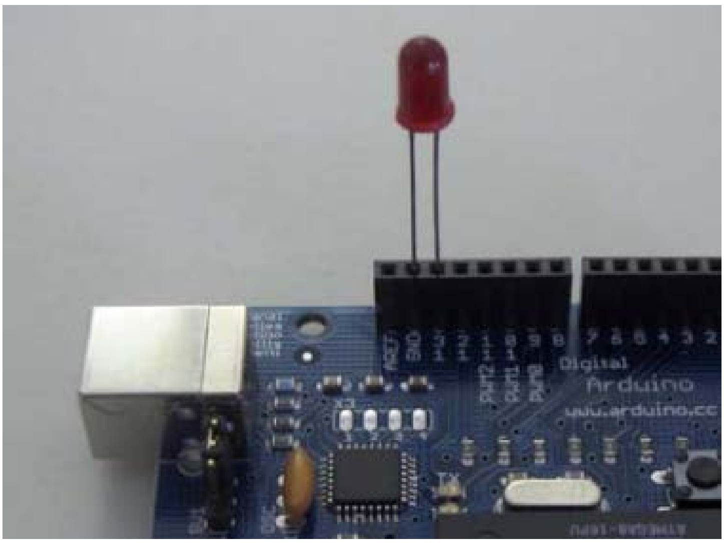


Fig. 3. The Arduino led blink circuit

Full code of sample led blink application.

```
int ledPin = 13;                    // LED connected to digital pin 13
void setup()
{
pinMode(ledPin, OUTPUT);            // sets the digital pin as output
}
void loop()
{
digitalWrite(ledPin, HIGH);         // sets the LED on
delay(1000);                        // waits for a second
digitalWrite(ledPin, LOW);          // sets the LED off
delay(1000);                        // waits for a second
}
```

4. Conclusion

We have presented Arduino, an open platform for electronics prototyping. We hope that Arduino demonstrates the potential of the open-source model to apply to hardware as well as software. Arduino attempts to eliminate or ease as many of the steps as possible with a combination of hardware and software.

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Introduction to Arduino Programming Language

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The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the wiring projects. It is designed to introduce programming to experts and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and auto-completion, and is also capable of compiling and uploading programs to the board with a single click. This paper is about how to program an Arduino.

1. Introduction

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer [1].

Arduino is a low-cost platform for embedded computing developed by a team of computer scientists and artists in Milan and New York. The Arduino is being used for inexpensive interactive applications developed with a bit of panache. The Arduino board is programmed using the Arduino programming language, which resembles C with a touch of C++ [2]. It is easy to construct robotic projects with Arduino.

2. Arduino Programming Environment

A program or code written for Arduino is called a "sketch" [3]. There are three main parts in Arduino code. These are variable declaration, the setup function, and the main loop function [4]. Additionally, there are comment lines. If comment is only one line it can be started with “//”characters. If comment is composed of many lines this comment is starts with “/*” and ends with “*/” characters. Comment lines are not executed. Arduino programming environment is shown in Fig. 1. The main parts are as follows:

2.1. Variable Declaration

Variable declaration is a fancy term that means you need to type the names of each input or output that you want to use in your sketch. It could be renamed an Arduino input/output pin number with any name (i.e., led_pin, led, my_led, led2, pot_pin, motor_pin, etc.) and it could be referred to the pin by that name throughout the sketch rather than the pin number. It could be also declared a variable for a simple value (not attached to an I/O pin) and use that name to refer to the value of that variable. Thus, when we want to use the value of the variable later in the sketch, it could be easy recalled. Below is a list of the data types commonly seen in Arduino programming, with the memory size of each stated in parentheses after the type name.

- boolean (8 bit)- simple logical true/false.
- byte (8 bit)- unsigned number from 0-255.
- char (8 bit)- signed number from -128 to 127.
- unsigned char (8 bit)- same as ‘byte’.
- word (16 bit)- unsigned number from 0-65535.

- unsigned int (16 bit)- the same as 'word'.
- int (16 bit)- signed number from -32768 to 32767.
- unsigned long (32 bit)- unsigned number from 0-4,294,967,295.
- long (32 bit)- signed number from -2,147,483,648 to 2,147,483,647.
- float (32 bit)- signed number from -3.4028235E38 to 3.4028235E38 [5].

The most common variable type that used is integer (int) type. Following is an example to variable declaration:
int my_led = 13;

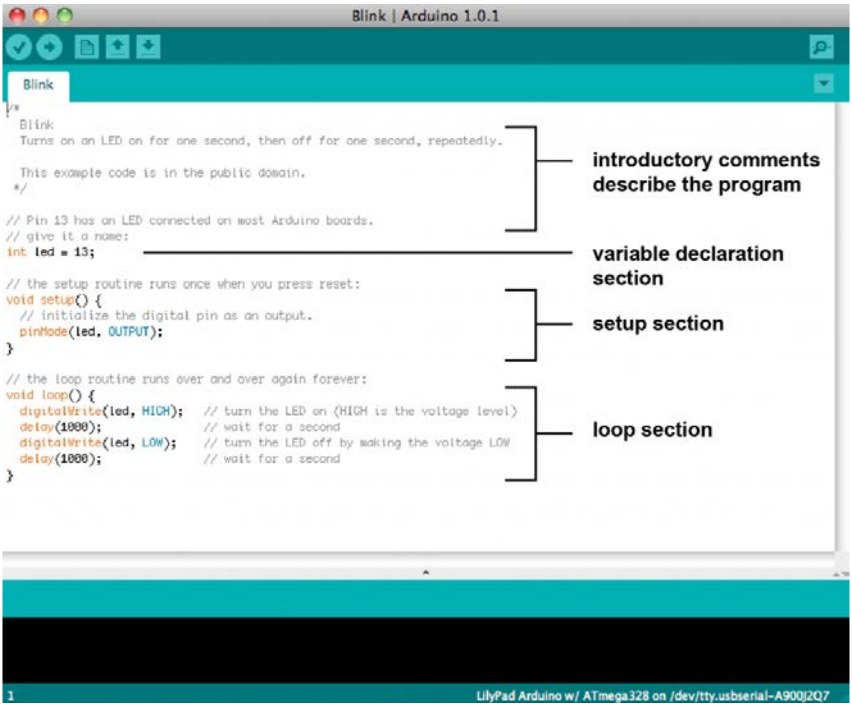

Fig. 1. Arduino programming environment

Instead of sending commands to the pin number of the Arduino (i.e., 13), pin 13 renamed as "my led" Anytime when we want to use pin 13, it could be called my_led instead. This is helpful for many references to my_led throughout the sketch. If we change the pin number my_led will be attached to (i.e., to pin 4), firstly we need to change the variable declaration and then all references to my_led lead to pin 4.

2.2. The Setup Function

This function runs once, each time the Arduino is powered on. In this part we define variables, declare input and outputs. pinMode() command is used to define variables.

Example setup() function:
void setup()

```
{
        pinMode(my_led, OUTPUT);
}
```

2.3. The Loop Function

This function is inserted where the main code is placed and will run over and over again continuously until the Arduino is powered off. This is where we tell the Arduino what to do in the sketch. Each time the sketch reaches the end of the loop function; it will return the beginning of the loop. In this example, the loop function simply blinks the LED on and off by using the delay(ms) function. Changing the first delay(1000) affects how long the LED stays on, whereas changing the second delay(1000) affects how long the LED stays off.

The following is an example loop() function:

```
void loop() {                       // beginning of loop, do the following things:
digitalWrite(my_led, HIGH);         // turn LED On
delay(1000); // wait 1 second
digitalWrite(my_led, LOW);          // turn LED Off
delay(1000); // wait 1 second       // end loop, go back to beginning of loop
}
```

If a program is combined with these sections of code together, a complete sketch is created. Your Arduino should have an LED built in to digital pin 13, so this sketch renames that pin my_led. The LED will be turned on for 1,000 milliseconds (1 second) and then turned off for 1,000 milliseconds, indefinitely until you unplug it.

Full code of Arduino _blink led;

```
int my_led = 13;                     // declare the variable my_led
void setup() {
pinMode(my_led, OUTPUT);                         // use the pinMode() command to set
                                    // my_led as an OUTPUT
}
void loop() {
digitalWrite(my_led, HIGH);                      // set my_led HIGH (turn it On)
delay(1000)                                      // do nothing for 1 second (1000ms)
digitalWrite(my_led, LOW);                       // set my_led LOW (turn it Off)
delay(1000);                                      // do nothing again for 1 second
}                                                // return to beginning of loop,
                                                 // end code
```

3. Conclusion

In this paper Arduino programming structure is presented. The main parts of code are introduced. Short examples are given to introduction to Arduino programming.

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Reading digital and analogue sensors with Arduino

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Arduino can sense the environment by receiving input from a variety of digital and analogue sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).

1. Introduction

1.1. Analogue Signals

The real world is not digital. Considering temperature fluctuation as an example, it changes within some range of values and generally does not make abrupt changes over time. We often measure environmental parameters like temperature, light intensity, or whatever using analogue sensors. These resulting signals are stored as sequential digital data.

An example would be to measure and record room temperature every minute. One could watch a thermometer and write down the readings. The sequence of data would look like (in Celsius): 20.3, 20, 20.5, 21, 20.8, etc.

We face a number of issues here. First of all Arduino cannot understand temperature as such, it needs to be translated into an electrical value. Second that electrical value has to be translated into a number that can be processed within Arduino.

As said, microprocessors cannot handle temperature values as humans do. We need to translate that into something the microchip can read. In order to do so, we can use sensors that will transform, in this case, temperature into a voltage value between 0 and 5 volts. These values are different from the HIGH and LOW that characterize digital signals, because they can take any value between 0 and 5 volts. 0.3 volts, 3.27 volts, 4.99 volts are possible values.

This is what we call an analogue signal. It differs from the digital ones in being able of taking many more than just two values. The amount of possibilities depends only in the capabilities of the processor/microcontroller you are working with in each case. Arduino can only distinguish 1024 different levels between 0 and 5 volts.

1.2. Analogue Sensors

Each sensor can translate a range of physical world values into electrical values. Let's imagine that our temperature sensor reads between 0C and 100C. Typically it should then assign 0 volts to 0C and 5 volts to 100C. Thanks to this we can easily translate levels of voltage into temperature.

The next issue has to do with the finite resolution of digital technology. Arduino has the possibility of reading values from the real world, which have been translated into electrical values between 0 and 5 volts. Try now to answer this question for a second: How many voltage values are there between 0 and 5 volts? The answer is simple: endless. Imagine two voltage values in the range we are working with, that are as close as possible, e.g. 3.4 and 3.41 volts. It is possible to have endless values in between those two: 3.401, 3.403, 3.402539, etc.

This means that we would need a processor with the ability to represent endless numbers, but Arduino cannot. Therefore, we speak about different levels. In particular Arduino divides the range of 0 to 5 volts into 1024 different voltage levels or intervals. 0 volts is in the interval 0, and 5 volts in the interval 1023. In this way, 2.5 volts would be in the interval 511 as well as 2.52 volts or 2.5103.

This operation of translating an analogue voltage value into different levels is what we call Analogue to Digital Conversion. One small hardware part inside the microprocessor that comes with the Arduino I/O board is dedicated to translate analogue voltages into these values: it is the Analogue to Digital Converter also called ADC.

1.3. Digital Signals

Digital signals are the way computers, microcontrollers, communicate with each other at a very low level. Digital signals coming into/from microcontrollers like the Arduino I/O board can only take two possible values: HIGH or LOW . A voltage equivalent characterizes each one of those. In the Arduino board HIGH is equivalent to 5 volts, while LOW is 0 volts. HIGH and LOW are not only having voltage equivalents, but also others at more logical and cognitive levels. The different equivalences for HIGH and LOW are described in the following table:

Level	Voltage Value	Logical Value	Cognitive Value	Machine Code
HIGH	5V	TRUE	ON	1
LOW	0V	FALSE	OFF	0

Remembering these relationships makes easier to understand the way digital electronics work and also how to program for the different types of sensors to be used with Arduino.

1.4. Digital Sensors

Digital sensors are sensors that are either on or off - full voltage or ground, 0 or 1. The simplest and most common digital sensor is a switch. Digital sensors are mainly used in water, wastewater and industrial processes. The measurement parameters such as pH, redox potential, conductivity, dissolved oxygen, ammonium, nitrate, SAC. A digital sensor system also consists of the sensor itself, a cable, and a transmitter.

2. Experimental Studies

This example shows you how to read analogue input from the physical world using a potentiometer. A potentiometer is a simple mechanical device that provides a varying amount of resistance when its shaft is turned. By passing voltage through a potentiometer and into an analogue input on your Arduino, it is possible to measure the amount of resistance produced by a potentiometer (or pot for short) as an analogue value. In this example you will monitor the state of your potentiometer after establishing serial communication between your Arduino and your computer.

Connect the three wires from the potentiometer to your Arduino board. The first goes to ground from one of the outer pins of the potentiometer. The second goes from 5 volts to the other outer pin of the potentiometer. The third goes from analogue input 0 to the middle pin of the potentiometer.

By turning the shaft of the potentiometer, you change the amount of resistance on either side of the wiper, which is connected to the center pin of the potentiometer. This changes the voltage at the center pin. When the resistance, between the center and the side connected to 5 volts, is close to zero (and the resistance on the other side is close to 10 kilohms), the voltage at the center pin nears 5 volts. When the resistances are reversed, the voltage at the center pin nears 0 volts, or ground. This voltage is the analogue voltage that you're reading as an input.

The Arduino has a circuit inside called an analogue-to-digital converter that reads this changing voltage and converts it to a number between 0 and 1023. When the shaft is turned all the way in one direction, there are 0 volts going to the pin, and the input value is 0. When the shaft is turned all the way in the opposite direction, there are 5 volts going to the pin and the input value is 1023. In between, analogueRead() returns a number between 0 and 1023 that is proportional to the amount of voltage being applied to the pin.

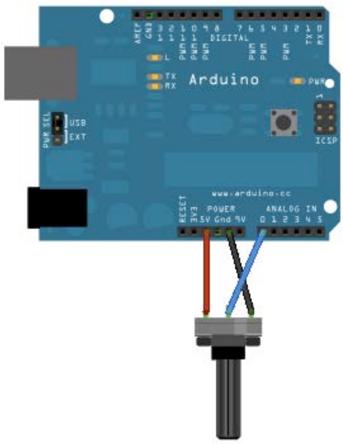

Fig. 1. Circuit of analogue read

2.1. Code:

```
/*
 AnalogueReadSerial
 Reads an analogue input on pin 0, prints the result to the serial monitor.
 Attach the center pin of a potentiometer to pin A0, and the outside pins to +5V and ground.
  */
// the setup routine runs once when you press reset:
void setup() {                     // initialize serial communication at 9600 bits per second:
 Serial.begin(9600);
}                                  // the loop routine runs over and over again forever:
void loop() {                              // read the input on analogue pin 0:
 int sensorValue = analogueRead(A0);       // print out the value you read:
 Serial.println(sensorValue);
 delay(1);                                 // delay in between reads for stability
}
```

Connect three wires to the Arduino board. The first two, red and black, connect to the two long vertical rows on the side of the breadboard to provide access to the 5 volt supply and ground. The third wire goes from digital pin 2 to one leg of the pushbutton. That same leg of the button connects through a pull-down resistor (here 10 KOhms) to ground. The other leg of the button connects to the 5 volt supply.

Pushbuttons or switches connect two points in a circuit when you press them. When the pushbutton is open (not pressed) there is no connection between the two legs of the pushbutton, so the pin is connected to ground (through the pull-down resistor) and reads as LOW, or 0. When the button is closed (pressed), it makes a connection between its two legs, connecting the pin to 5 volts, so that the pin reads as HIGH, or 1.

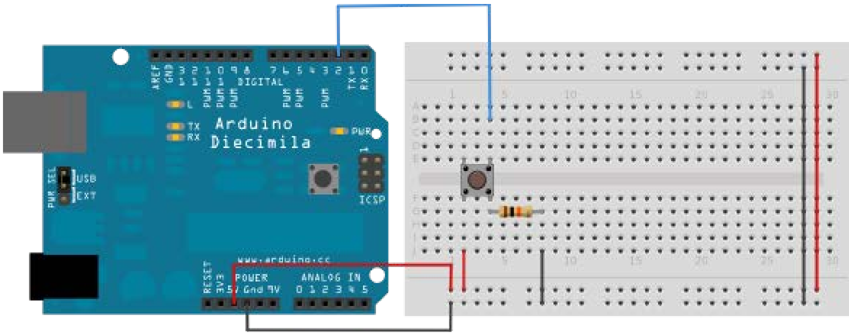

Fig. 2. Circuit of analogue read

If you disconnect the digital i/o pin from everything, the LED may blink erratically. This is because the input is "floating" - that is, it does not have a solid connection to voltage or ground, and it will randomly return either HIGH or LOW. That's why you need a pull-down resistor in the circuit.

2.2. Code :

```
/*
 DigitalReadSerial
 Reads a digital input on pin 2, prints the result to the serial monitor
 This example code is in the public domain.
 */

// digital pin 2 has a pushbutton attached to it. Give it a name:
int pushButton = 2;

// the setup routine runs once when you press reset:
void setup() {                    // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);             // make the pushbutton's pin an input:
  pinMode(pushButton, INPUT);
}

// the loop routine runs over and over again forever:
void loop() {                                   // read the input pin:
  int buttonState = digitalRead(pushButton);    // print out the state of the button:
  Serial.println(buttonState);
```

```
  delay(1);                                    // delay in between reads for stability
}
```

A rotary or "shaft" encoder is an angular measuring device. It is used to precisely measure rotation of motors or to create wheel controllers (knobs) that can turn infinitely (with no end stop like a potentiometer has). Some of them are also equipped with a pushbutton when you press on the axis (like the ones used for navigation on many music controllers). They come in all kinds of resolutions, from maybe 16 to at least 1024 steps per revolution.

I have written a sketch to read a rotary controller and send its readout via RS232. It simply updates a counter (encoder0Pos) every time the encoder turns by one step, and sends it via serial to the PC.

This works fine with an ALPS STEC12E08 encoder which has 24 steps per turn. I can imagine it could fail with encoders with higher resolution, or when it rotates very quickly (think: motors), or when you extend it to accommodate multiple encoders.

This example shows you how to monitor the state of a switch by establishing serial communication between your Arduino and your computer over USB.

2.3. Code:

```
/* Read Quadrature Encoder
  * Connect Encoder to Pins encoder0PinA, encoder0PinB, and +5V.
 int val;
 int encoder0PinA = 3;
 int encoder0PinB = 4;
 int encoder0Pos = 0;
 int encoder0PinALast = LOW;
 int n = LOW;
 void setup() {
   pinMode (encoder0PinA,INPUT);
   pinMode (encoder0PinB,INPUT);
   Serial.begin (9600);
 }
 void loop() {
   n = digitalRead(encoder0PinA);
   if ((encoder0PinALast == LOW) && (n == HIGH)) {
     if (digitalRead(encoder0PinB) == LOW) {
       encoder0Pos--;
     } else {
       encoder0Pos++;
     }
     Serial.print (encoder0Pos);
     Serial.print ("/");
   }
          encoder0PinALast = n;
 }
```

3. Conclusion

Most of engineering applications are combined with variety of digital and analogue sensors. In this study, we have demonstrated to read analogue and digital signal with examples. Arduino can read all environmental impacts easily with these sensors. Arduino can combine all environmental devices easily and provides us with the possibility of easy use.

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Digital inputs on Arduino UNO R3 a microcontroller circuit board

Nedjeljko Jedvaj
Elektrostrojarska škola u Varaždinu

The aim of the exercise: To learn ways to combine buttons, and switches on a microcontroller, programming and reading the state of the digital inputs, as well as the use of "if" command.

Required materials and supplies: Arduino board, LCD and LED expansion module, USB cable

1. Introduction

Digital ports on the Arduino board can be input and output. If digital connections are used as inputs then they start being part of the system and they can then connect various sensors that collect discrete information. These data can serve to manage some systems. On the digital input the microcontroller receives binary information corresponding to the state of buttons or switches when contacts closed or open (logical unit or logical zero). The data entry is performed, settings are changed, and the operation of microcomputers is controlled by buttons or switches connected to the microcomputer.

There are mainly three ways to connect push buttons and switches on the Arduino: a pull-down resistor, a pull-up resistor and without pull- up or pull-down resistors. If you use a pull-down method, the pushbuttons are connected to ground via a resistor of 10kΩ as shown in Fig. 1.1 . When the button is pressed it will close the circuit through the resistor, and then, on the digital input the command digitalRead () will be used and it will read high. If the button is not pressed no current flows through the circuit, and the digital input will read low. Resistor R1 only has the function of protecting the port by limiting current in the event of an error, if we put the connection on low state.

Another way of connecting is with the so-called pull-up resistor. When the button is open, the circuit is closed and there is no voltage drop across the resistor R2. Therefore, the digital port reads the status of a logical unit. Closing the circuit results in voltage drop across the resistor and at that moment we read the logical zero state. Resistor R1 protects the entrance here, in case you mistakenly put a high state of the connection.

The third way of connecting the push button or switch is the easiest, because there is no need for external resistors. They are already being used internally. The principle of operation is the same as for external pull-up resistors, but they must be initialized before reading status command.

pinMode (buttonPin, INPUT_PULLUP);

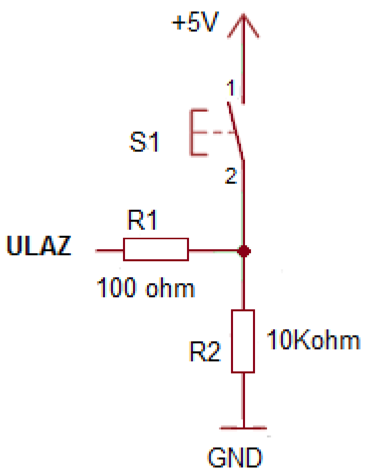

Fig. 1.1. Connecting the switch with a pull-down resistor

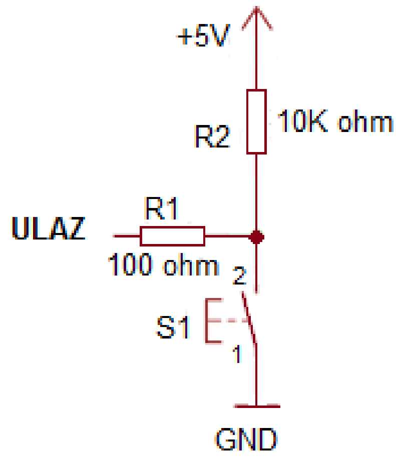

Fig. 1.2. Connecting the switch with pull-up resistor

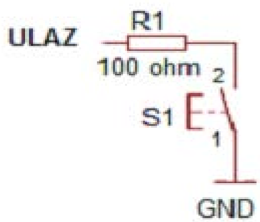

Fig. 1.3. The third way of connecting push buttons and switches on pin input

2. Exercise

Create a program that includes a light-emitting diode but only when the button is pressed on the digital input port. The push button is on the port 8 and is without an external resistor, while the LED is on port number 7

The command to read the state of the digital input is

digitalRead (8);

where we read the state of the digital input number 8.

2.1. Example:

input_state = digitalRead (8); // input_state of a variable has a value of 1 or 0

Here, the return value of the function digitalRead should be joined to another variable (in our case it is input_state).
Now we can write the source code of the program.

2.2. Program:

```
int button_1 = 8;                          // on the port number 8 of an Arduino
                                           //board there is button.
LED_7 int = 7;                             // a light emitting diode is on the port
                                           //number.
State_button_1 int = 0;                    // the variable temporarily remembers
                                           //state of the button.
void setup ()                              // initialization is done only once.
{
   pinMode (button_1, INPUT_PULLUP);       // button_1 is an input with
                                           //internal pull-up resistor.
   pinMode (LED_7, OUTPUT);                // LED_7 the  output.
}
void loop ()                               // this part is continuously repeated.
{
  state_button_1 = digitalRead (button_1);  // read the state of the buttons.
  if (state_button_1 == LOW)               // if  button  is pressed  we read logical
                                           //zero and ...
  {
          digitalWrite (LED_7, HIGH);      //  includes a light emitting diode.
  }
  else                                     // if the button is released ...
  {
          digitalWrite (LED_7, LOW);// turns off the LED.
   }
}
```

2.2. Program with if statement:

An if statement is a conditional branching, and the general form is:

```
if (condition)
{
          block command_1
}
else
{
          block_command_2
}
```

First the condition will be examined and if it is filled, blok_command_1 will be performed, and if the condition is not fulfilled blok_command_2 is performed. If the condition is not met, and we do not want to execute a block command_2 part of the command "else" may be omitted. In this case, the general form of the command is "IF"

```
if (condition)
{
        block _commands
 }
```

The block commands are executed only if the condition is met. Otherwise, the program proceeds to the next command. Again, as in previous cases block commands can contain only one command inside the braces.

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

3.1 Change the source code of the program so that button_1 at port 8 includes a light-emitting diode, and button_2 at port 9 is off. LED is on port number 7

3.2 Write a program that is executed so as to simulate the turn signals on the car. Push buttons are on connectors 8 and 9, and LEDs are on 6 and 7.

For further reading student could refer to other books published about robotics [1] or about Arduino [2].

REFERENCES

[1] Niku, Saeed Benjamin, Introduction to robotics, Upper Saddle River : Prentice Hall, cop. 2001

[2] Massimo Banzi, Getting Started with Arduino, O'Reilly Media, Inc. 2011

[3] Michael McRoberts, Beginning Arduino, Apress, 2010

[4] http://www.arduino.cc/

Digital outputs on Arduino UNO R3 a microcontroller circuit board

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Aim of the exercise: To introduce students to the Arduino development environment [3]. To learn the basic operations of the program management of microcontroller's digital outputs, as well as the use of "for" statement.

Required materials and supplies: Arduino circuit board, LCD and LED expansion module, USB cable

1. Introduction

In digital circuits the sum of signals has one of two mutually different values that are different enough. The voltage of the digital signal can take one of only two possible values. These values are values of high levels H (from Eng. high) and the values of low levels L (from Eng. low). The signal cannot have values of voltage levels between H and L. Voltages of low and high levels can deviate from the nominal value so we talk about areas of low and high levels.

In practice, low voltage values are between 0 and 0.8 V, and high levels are of between 2 and 5V. When digital connections are used as outputs then, they are the final parts of the system that some elements, which we operate, connect to. Light-emitting diode (LED) is a special type of diode that emits light when current flows through it and is used as a signalling and a control element. The intensity of the light depends on the strength of the current passing through it. It has excerpts to connect the positive terminal, the anode (longer excerpt) as well as to connect the negative pole, or cathode (short excerpt). Cathodes can be often identified by the flat part of the edge of the casing.

Fig. 1.1. LED

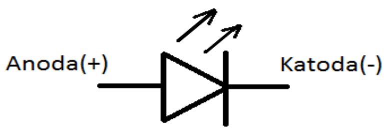

Fig.1.2. Graphical symbol of LEDs

There are two possible ways of connecting the LEDs on the Arduino: the cathode or the anode is connected to the Arduino. In the first case, the LED will light up if there is a low status on the terminal (pin) of Arduino or 0 V, while in the second case we bring high status to the Arduino terminal or 5V. Connecting the LED on the connector is done so that a serial resistor to limit the current flow is added.

Arduino UNO R3 incorporates a small sized LED (SMD) at terminal D13, where the LEDs anode is connected to the Arduino D13 connector plate and the cathode is connected to the negative terminal of the power supply. This means that the LED lights up when the D13 is set high (as a logical one). Low levels on the same port will turn off the LED.

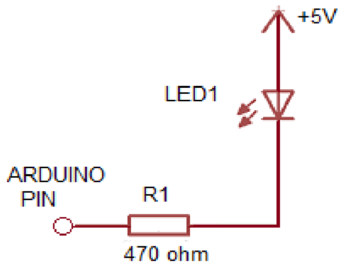

Fig. 1.3. Switching LED on with low state

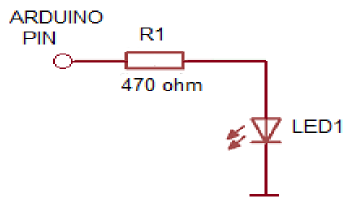

Fig.1.4. Switching LED on with high state

2. Exercise

Create a program for Arduino so it will constantly turn on and off the LED on the pin D13 with an interval of 0.5 seconds.

At the beginning of the program it is necessary to declare a connection,

Const int ledPin = 13 ,

and within the "Setup" function we need to determine whether to use the port as input or output. If we use it as a way out then write "OUTPUT".

PinMode (ledPin, OUTPUT)

In the main part of the program that is the "loop" we use the command digitalWrite (), which sets the high state to the digital connection.

2.1. Example:

digitalWrite (ledPin, HIGH)

Will set the "ledPin" to high state (or 5V).
Duration of inclusion digital output can delay the introduction of the command.

delay (1000); //1000 milliseconds, or one second

Number within brackets defines the amount of delay in milliseconds.

We turn off light diodes with the command

digitalWrite (ledPin, LOW)

2.2. Program:

```
int LED = 13;                       // an LED is on the port number 13 of an Arduino
                                    // board . Pin is declared in the same way as any other
                                    // variable.
Void setup ()                       // initialize
{
    pinMode (LED, OUTPUT);          // port LED will be used as a digital output (Eng.
                                    //output)
}
void loop ()                        // this part of the program is continuously repeated
{
   digitalWrite (LED, HIGH);        // include light-emitting diode (HIGH means high state
                                    //or voltage 5 volts),
   delay (1000);                    // we wait 1000 milliseconds or 1 second.
  digitalWrite (LED, LOW);          // we turn off the LED (LOW means low status or 0
                                    //volts),
  delay (1000);                     // again, we wait for one second.
}
```

2.2. Program with for statement:

The command "for" of the loop is used when we want to execute the same command or group of commands a number of times. In the following example, the commands within the "for" loop are executed 4 times.

```
for (i = 0; i < 4; i + +)
{
     digitalWrite (LED_pin, HIGH);
          delay (500);
          digitalWrite (LED_pin, LOW);
          delay (500);
}
```

The general form of "for" statement is

```
for (initial expression; condition performing loops, command)
{
                         // block of commands
}
```

The initial expression is executed only once, and with each passing through the loop it tests whether the condition has been made. If the condition is met it executes a block of statements within braces, and then executes the command as the third term "for" loop. If the performance requirements of the loop are not met, a block of commands will not be executed, and moves to the next command. Command block can contain only one command.

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

3.1 Build a program so that it turns on and off 2 LEDs on ports 2 and 3 in 1 second intervals 5 times, using a "for" command.

3.2 Write a program that simulates the operation of traffic lights. In doing so, use the LEDs on ports 5,6 and 7.

For further reading student could refer to other books published about robotics [1] or about Arduino [2].

REFERENCES

[1] Niku, Saeed Benjamin, Introduction to robotics, Upper Saddle River : Prentice Hall, cop. 2001

[2] Massimo Banzi, Getting Started with Arduino, O'Reilly Media, Inc. 2011

[3] Michael McRoberts, Beginning Arduino, Apress, 2010

[4] http://www.arduino.cc/

Serial communication on Arduino UNO R3 a microcontroller circuit board

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The aim of the exercise: To grasp the principles of serial communication and learn the ways of receiving and transmitting data.

Required materials and supplies: Arduino circuit board, LCD and LED expansion module, USB cable

1. Introduction

Microcontrollers ATmega with which Arduino circuit board is made has an integrated serial port which enables serial communication in several ways. This connection is used to communicate with other computers or peripherals such as a printer. In this way it is possible to make a wireless connection to another computer e.g. via Bluetooth or WiFi communication.

USB port that is used to transfer the machine code from the personal computer to the Arduino can be used to communicate with the computer during the execution of the program. In this way we receive and transmit data such as the condition of a variable or simply print a message on the terminal of a PC (serial monitor). When installing the Arduino development environment a driver for serial communication will be installed and along with a USB-serial converter on the plate it simplifies the use of USB ports, because we use simple commands for a serial port (COM). The main menu runs a monitor program through which the keyboard sends data and at the same time we can see the data that arrived at the serial interface.

Fig. 1.1. Starting the monitor program

The initialization of the serial interface is done by command

Serial.begin (9600),

Where the number inside the parentheses is the sum of bits per second transmitted. We put this command in the Setup () subroutine. The command with which it prints the value of a certain variable is

Serial.Println (val) *// val is the variable's name.*

Similarly, we can print the text as

Serial.Println ("Arduino")

The difference between the commands Printl and the Print is that the Print command does not add control characters CR and LF which prepare the next print at the beginning of a new order. Numerical values can be printed in hexadecimal, octal or binary form. Then after the variable's name we write key words HEX, OCT and BIN.

For example:

```
Serial.Println (val, HEX);     // print variable values in hexadecimal format.
Serial.Println (val, OCT);     // print the value of the variable in octal form.
Serial.Println (val, BIN);     // print variable values in binary form.
```

The previous commands print numeric values and text as ASCII characters. If you need to print binary data then instead of Print or Println we use the command write,

Serial.write (val);

This command will send a byte wave as a series of bits, through the serial port

Reading data from the serial interface in the main loop requires us to check the availability of the data in the data buffer. This can be done using the command

Serial.available ()

This command will give us the number of bytes of data in the cache serial interface ready for reading. The reading can be accessed if at least one data is in the data buffer.

This software can perform this way:

```
if (Serial.available ()> 0) {...     // read the data}
```

Command to read *Serial.read ()* returns the read data, or -1 if the serial interface of the data buffer is empty. We can use it in this way:

```
data = Serial.read ();     //data previously declared variable
```

2. Exercise

Make a program for Arduino to control the switching on and switching off the LEDs via serial communication. The condition of LEDs should be visible on the PC's terminal.

2.1. Program:

```
int LED = 7;                  // LED on the pin #7
char val;                     // declaration of a variable "val."
Void setup ()
{Serial.begin (9600);         // initialize the serial port baud rate to
                              //9600 bps.
```

```
            pinMode (LED, OUTPUT);                  // LED is defined as output.
}
void loop ()                                        // main loop
{
            if (Serial.available ()> 0)             // If an information on the serial port
                                                    // is accepted ...
            {val = Serial.read ();                  // .. We read it and join it to the
                                                    // variable "val."
                        if (val == 'a')             // If the character is letter "a" ...
                        {
                                    digitalWrite (LED, HIGH); // ... turning on LED. ..
                                    Serial.println ("LED ON"); // ... send a text to a personal
                                                    //computer.
                        }
                        else if (val == 'b')        // If the accepted  character is
                                                    //the letter "b" ...
                        {
                        digitalWrite (LED, LOW);    // ... turning off LED ..
                        Serial.println ("LED OFF"); // ... sending a message.
                        }
            }}
```

2.2. Running and monitoring program

After transferring to Arduino we can run a monitor program as previously described for monitoring the work of a serial port. We write the text or in our case a letter that we want to send to the Arduino in the top line and press the enter key or activation button "send" and the file transfer begins.
The lower larger window prints text that a personal computer is receiving from another device, in our case it is the Arduino.

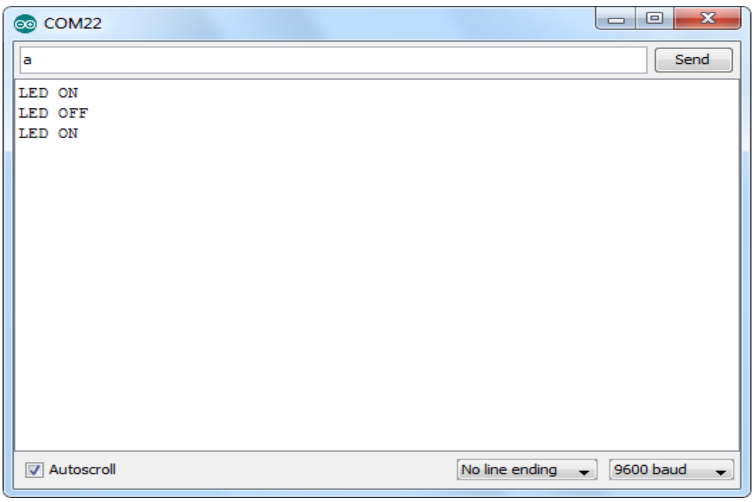

Fig. 1.2. Monitor of serial communication

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

3.1 Write a program that works in a way that it reads the condition of pushbuttons on the connectors 8 and 9 and then via serial communication prints to monitor that button that is pressed (1 or 2).

3.2 Build a program to simulate the work of traffic lights which can be controlled through a serial port. Symbol "r" turns on the red light, "y" yellow, and "g" green. LEDs are on terminals 5, 6 and 7.

For further reading student could refer to other books published about robotics [1] or about Arduino [2], [3].

REFERENCES

[1] Niku, Saeed Benjamin, Introduction to robotics, Upper Saddle River : Prentice Hall, cop. 2001

[2] Massimo Banzi, Getting Started with Arduino, O'Reilly Media, Inc. 2011

[3] Michael McRoberts, Beginning Arduino, Apress, 2010

[4] http://www.arduino.cc/

Analogue inputs on Arduino UNO R3 a microcontroller circuit board

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The aim of the exercise is to distinguish between digital and analog voltage value and the use of the microcontroller's analog input.

Required material and supplies: Arduino tile, TinkerKit board for expansion, potentiometer module with cable connectivity, USB cable.

1. Introduction

The analog value represents the amplitude of the input signal, and the size of the binary digital signal of a number of bits. Inside the microcontroller is a circuit that is called analog-to-digital converter with 10-bit resolution. The voltage resolution is the amount of change in the analog input values to output that changes the digital output size to one bit, and we can calculate it by using this formula:

$$\frac{U_{uFS}}{2^{n} - 1}$$

Where UuFS is the maximum amount an analog voltage that can be lead to the input and n is the number of bits of digital output size. Arduino contains a 10-bit AD converter (n = 10), and the largest amount of analog voltage in our case is 5V. On the board there are 6 analog inputs (A0-A5).

The command to read the analog input is analogRead (pin), where the pin is an analog pin.
Reading the state of an analog input can be made like this:

```
sensorVal = analogRead (sensorPin)          // sensorVal variable is associated
                                            //with an actual reading
                                            // value, and sensorPin the input
                                            // port (A0.. A5).
```

Since the AD converter has 10 bits, the variable "sensorVal" can take on any value from 0 to1023. To get the amount of input voltage in volts it is necessary to multiply this value with the previously calculated voltage resolution. You need to know that time of AD conversion with Arduino is set to be longer than 0.1 ms, so it is necessary to generate the program delay after reading the state of the analog input.

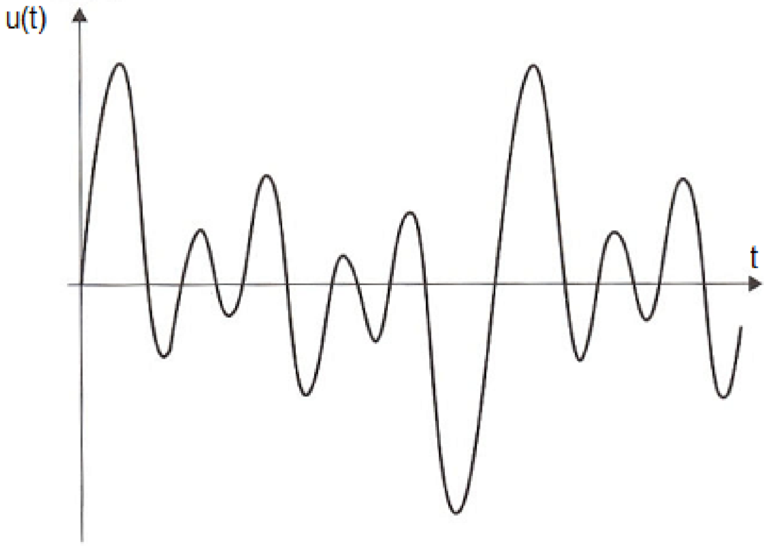

Fig. 1.1. Analog signal

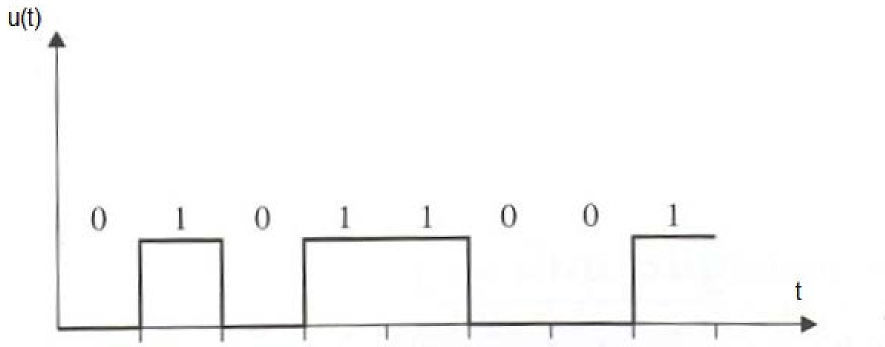

Fig. 1.2. Digital signal

2. Exercise

Create a program for the Arduino where digitized value of the analog signal that is adjusted by the potentiometer connected to the analog input A2 is sent to the serial interface.

2.1 Program:

```
int AnalogInPin = A2                    // we use the analog input A2
int = 0;                                // variable that stores the read value .
void setup ()                           // Initialization
{
        Serial.begin (9600);            // initialize the serial port baud rate to 9600
                                        // bps.
```

```
}
void loop ()                                  // main loop
{
        read_value = analogRead (AnalogInPin);     // AD conversion
        Serial.print ("Input A2");                 // Sends a text and. ..
        Serial.println (read_value);               // display an AD
                                                   //conversion result.
        Delay (2);                                 //delay of 2 ms.
}
```

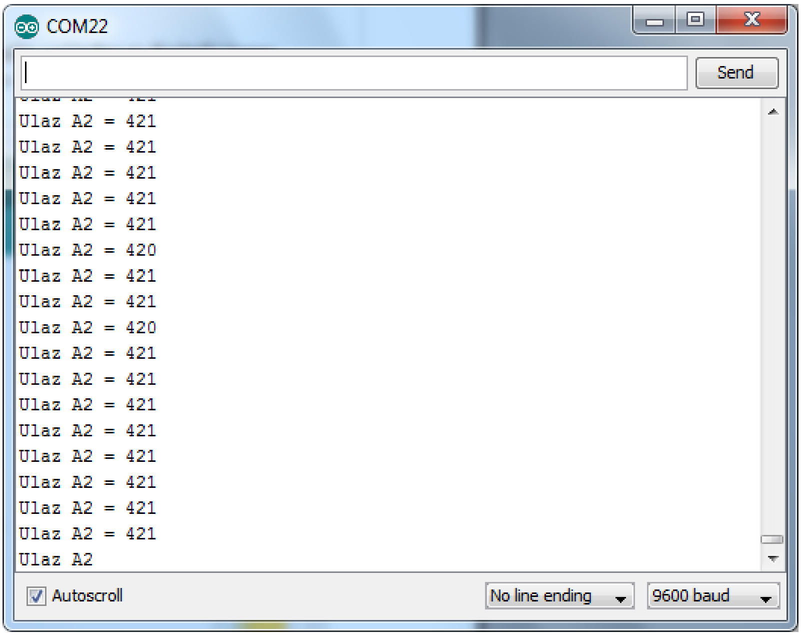

Fig. 1.3. The readings of analog input on your monitor

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

3.1 Replace the potentiometer with a photo-resistor and watch the readings.
3.2 Write a program for the Arduino to be executed by sending the readings of voltage that is from 0 to 5 V and is adjusted by a potentiometer, to the serial interface.

For further reading student could refer to other books published about robotics [1] or about Arduino [2].

REFERENCES

[1] Niku, Saeed Benjamin, Introduction to robotics, Upper Saddle River : Prentice Hall, cop. 2001

[2] Massimo Banzi, Getting Started with Arduino, O'Reilly Media, Inc. 2011

[3] http://www.arduino.cc/

Analogue outputs on Arduino UNO R3 a microcontroller circuit board

Dubravko Tomasović, Nedjeljko Jedvaj
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Aim of the exercise: To understand the principles of pulse-width modulation signals as well as to learn ways of software based generation of analog signals. Learn the application of the statement *while*.

Required materials and supplies: Arduino circuit board, LCD and LED expansion module, and a USB cable

1. Introduction

Ports 3, 5, 6, 9, 10,11 on the Arduino board can be used to generate the analog voltage values of 0 to 5V. This is often used to control the speed of electric motors or to adjust the intensity of the light sources. Digital-to-analog converter converts the digital amount to an analog value. Since Arduino has no standard DA converter we use PWM (pulse width modulation Engl.) technique or pulse-width modulation. Pulse width modulation is a way of getting an analog value via digital. Duration of impulse recurring digital pulses determines the value of the voltage supplied. If the duration of the impulse (width) is greater and the duration of the pause shorter, the voltage at the output is higher. Getting different analog values is achieved by changing the pulse width. If this pattern is repeated at a certain frequency, the result is the same as if the signal is a constant voltage between 0V and 5V. The frequency of a PWM signal is approximately 490Hz.

The command to generate analog voltage level at the pin is

```
analogWrite (pin, val);          // pin serial port number, and the val is a numeric value
                                 // from 0 to 255.
```

Since the DA conversion with the PWM technique to the Arduino Uno R3 is 8-bit, the values used to generate analog signals are from 0 to 255. In this case zero represents 0V and 255 is 5V. The desired voltage at the output and can easily be calculated from

$$U = (Uref / 255) * val [V]$$

where Uref is the reference voltage (5V), and the val is the numerical value of DA conversion (0-255)

2. Exercise

Write a program for the Arduino so it constantly changes light intensity of LEDs from low to the high on the pin, and then vice versa.

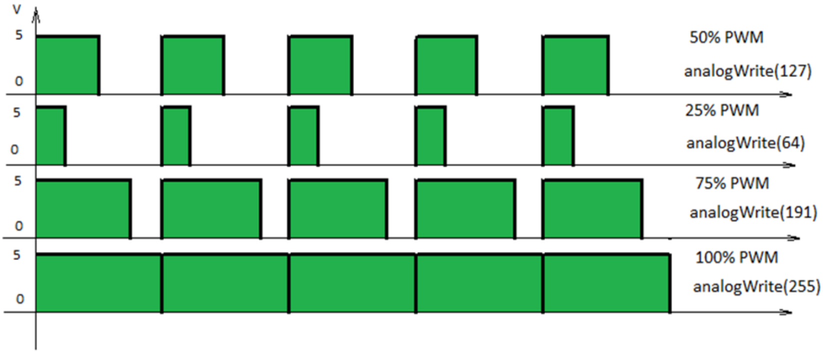

Fig. 1. Pulse-width modulation (PWM)

2.1. Example:

Since the Arduino UNO R3 supports the standard PWM only on ports 3, 5, 6, 9, 10 and 11 we will choose one of those to be connected to LED.

Here we use the command *while* with the purpose of the conditional execution of the loop repetition. The general form of this command is

while (condition)

{block

of

commands}

In these types of loop condition is tested at the beginning, a command block loop is repeated until the condition is met. Since conditions are examined at the beginning it may happen that the block commands loop does not execute even once.

2.2. Program:

```
int LED = 6;                          // LED on the connector number 6
int i = 0;                            // Declare variables
void setup ()
{
        pinMode (LED, OUTPUT);        // initialize port as output.
}
void loop ()                          // main loop
{
```

```
        while (i < 255)                    // As long as the variable is less than 255 ..
        {
                analogWrite (LED, i);      // DA conversion; we send the value of the
                                           // variable "i"
                delay (5);                 // Delay 5ms to slow down to execute a
                                           // program.
                i++;                       // increasing variables (light intensity) for 1
        }
        while (  i > 0)                    // The second conditional loop to reduce the
                                           // LED intensity ..
        {                                  //.. is executed until the variable is greater than
                                           // 0 and
                analogWrite (LED, i);      // DA conversion
                delay (5);                 // Again delay 5ms
                i--;                       // decreasing variable by 1
        }
}
```

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

2.3.1 Modify the program so that it also changes the intensity of light on light-emitting diodes that are connected to 6 and 3, but in a way the port 6 has the largest, and port 3 has the lowest voltage and vice versa.

2.3.2 Write a program for Arduino that will run so that pressing one of the four pushbuttons generates an analog voltage value on port 6. Pressing the first button gives you 100% of the voltage, the second 75%, the third 50%, and 0% in the fourth. The buttons are on ports 8, 9, 10 and 11.

For further reading student could refer to other books published about robotics [1] or about Arduino [2].

REFERENCES

[1] Niku, Saeed Benjamin, Introduction to robotics, Upper Saddle River : Prentice Hall, cop. 2001

[2] Massimo Banzi, Getting Started with Arduino, O'Reilly Media, Inc. 2011

[3] http://www.arduino.cc/

RC servo control with Arduino UNO R3 a microcontroller circuit board

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The aim of the exercise: Learn the methods of programming control, of RC servo motors for positioning and continuous rotation.

Required materials and supplies: Arduino circuit board, TinkerKit expansion board, RC servo motors for positioning and continuous rotation, USB cable

1. Introduction

RC servo motors due to their ease of use and compact structure are often used in model making techniques and making of models of robots, which can be found in various designs and dimensions. Suitable for positioning, usually in the range 0 -180 ° angle, but there are also versions for the continuation of the rotation.

Fig. 1. RC servo motor

Basic components of an RC servo motors are: DC electric motor, reduction gears, and control electronics. Built-in potentiometer is used to measure the rotation angle that is part of a feedback control unit that allows the control electronics to put the output shaft of RC servo electric motors placed in the desired position. To manage the shifting of the angle or the speed of rotation with continuous performances is conducted by a special pulse-width modulation

(PWM). It takes approximately 30 to 50 pulses per second, and the duration of which is determined by the rotation angle or speed.

If it comes to the performance of RC servo electric motors for positioning the pulse duration of 1.5 ms will maintain the shaft in the middle or neutral position. Pulse that is 1 ms wide rotates the shaft in one and 2 ms in the opposite direction. Depending on the values between the axles of the RC servo electric motor it will be placed in a certain position. Another aspect of the RC servo electric motor is a continuation of the rotation. Here the pulse duration of 1.5 ms stops the spinning, and gradually increasing the duration to 2 ms will increase the speed of continuous rotation direction. Reducing the pulse duration to 1 ms will increase the speed of rotation in the other direction.

2. Exercise

Write a program that works for the Arduino so that the RC servo motor for continuous rotation turns at top speed in one direction for 5 seconds, then pauses for 2 seconds, and then repeats the rotation in the opposite direction for a period of 3 seconds. After a pause of 2 seconds, the cycle is repeated.

2.1. Example:

To be able to use the commands to control the RC servo motors, at the beginning of the program we need to add a file Servo.h with a preprocessor command.

```
# include <Servo.h>
```

Within the subroutine setup we need to add a row

```
myservo.attach (4);                // servo is added to pin number 4
```

Electric servo motor is controlled by the command

```
myservo.write (val);               // where the val is a variable that has a value from 0 to 180
```

Here pulses of duration of 1.5 ms will be generated if we send the value of 90, for a pulse of 1 ms, it is necessary to send a value of 0, and for the pulse of 2ms we send 180.

2.2. Program:

```
#include <Servo.h>                 // need to add the file for servo electro-motors
Servo myservo;                     // declaration of objects
void setup()
```

```
{
        myservo.attach(4);              // servo is added to connection number 4.
 }
void loop()
{
        myservo.write(180);             // Maximum speed of rotation in one direction
        Delay(5000);                     // Duration is approximately 5 seconds.
        myservo.write(90);              // Stop
        delay(3000);                    // 3 second pause.
        myservo.write(0);               // Maximum speed of rotation in  the other direction
        delay(5000);                    // Duration is approximately 5 seconds.
        myservo.write(90);              // Stop
        delay(3000);                    // 3 second pause
}
```

3. Results and conclusions

According to presented materials students should be able to solve next tasks:

3.3.1 Write a program for the Arduino, which will run in a way it will receive commands: "L", "D" and "S" via serial interface. Character "L" is the command that will run the RC servo at top speed in one direction, "D" in the other direction, and the "S" will stop the RC servo motor.

3.3.1 Change the program from the previous task so that the RC servo motor while working controls three buttons on ports 8, 9 and 10.

For further reading student could refer to other books published about robotics [1] or about Arduino [2].

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DC motor driver with Arduino

University of Karabuk, Faculty of Technology (P4),
Transferring, Adopting and Developing Software (WP5)

The Arduino Motor Shield is based on the L298, which is a dual full-bridge driver designed to drive inductive loads such as relays, solenoids, DC and stepping motors. It lets you drive two DC motors with your Arduino board, controlling the speed and direction of each one independently. You can also measure the motor current absorption of each motor, among other features.

1. Introduction

The Arduino Motor Shield must be powered only by an external power supply. Because the L298 IC mounted on the shield has two separate power connections, one for the logic and one for the motor supply driver. The required motor current often exceeds the maximum USB current rating.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. Plugging a 2.1 mm centre-positive plug into the Arduino's board power jack on which the motor shield is mounted or can connect the adapter by connecting the wires that lead the power supply to the Vin and GND screw terminals, taking care to respect the polarities.

To avoid possible damage to the Arduino board on which the shield is mounted, we recommend using an external power supply that provides a voltage between 7 and 12V. If your motor requires more than 9V we recommend that you should separate the power lines of the shield and the Arduino board on which the shield is mounted. This is possible by cutting the "Vin Connect" jumper placed on the backside of the shield. The absolute limit for the Vin at the screw terminals is 18V.

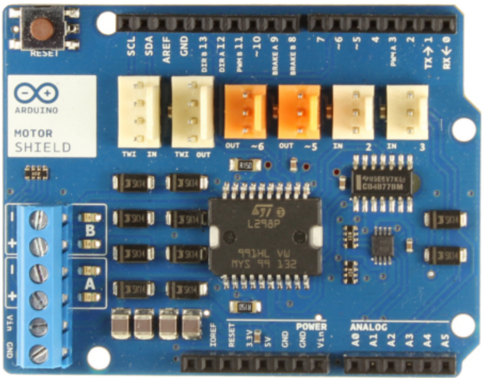
2. Materials and Methods

This shield has two separate channels, called A and B, that each use 4 of the Arduino pins to drive or sense the motor. In total there are 8 pins in use on this shield. You can use each channel separately to drive two DC motors or combine them to drive one bipolar stepper motor. Arduino motor shield is shown in Fig. 1. The shield's pins, divided by channel are shown in the table below:

Table : Motor driver Functions

Function	Pins per Ch. A	Pins per Ch. B
Direction	D12	D13
PWM	D3	D11
Brake	D9	D8
Current Sensing	A0	A1

If you do not need the Brake and the Current Sensing and you also need more pins for any application you can disable these features by cutting the respective jumpers on the backside of the shield.



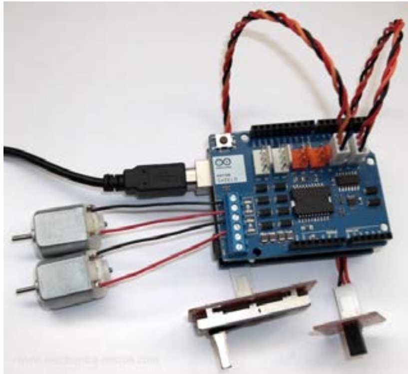


Fig. 1. Arduino motor shield

Fig. 2. DC motor control with Arduino motor shield

You can drive two Brushed DC motors by connecting the two wires of each one in the (+) and (-) screw terminals for each channel A and B. In this way you can control its direction by setting HIGH or LOW the DIR A and DIR B pins, you can control the speed by varying the PWM A and PWM B duty cycle values. The Brake A and Brake B pins, if set HIGH, will effectively brake the DC motors rather than let them slow down by cutting the power. You can measure the current going through the DC motor by reading the SNS0 and SNS1 pins. On each channel will be a voltage proportional to the measured current, which can be read as a normal analogue input, through the function analogRead() on the analogue input A0 and A1. For your convenience it is calibrated to be 3.3V when the channel is delivering its maximum possible current that is 2A. Dc motor and battery connections of Arduino motor shield are shown in Fig. 2.

Below is a simple program the Arduino code to speed control a DC motor.

```
int pot= A5;
int value;
void setup() {}
void loop() {
value = analogRead(pot);
value = map(value, 0, 1023, 0, 225);
analogWrite(5, value);
delay(10);
}
```

3. Conclusion

In this study, we have presented the Arduino Motor Shield which is based on the L298. It provides many advantages because in this way there is no need to set the circuit.

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Didactic tool eProDas-Rob1 as a working tool for gifted students

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The article presents the usage of didactic tools and e-working material for gifted students. As the basic working method with such students, the method of trial and error was used – planning and execution of the research and participation on the competition of young researchers. Influence of the research work on the gifted student is shown on the study case of three students with various interests but with a strong desire to succeed and to get recognition. The great help in working with gifted students can also be the professional and other experience, which can be gained through the active participation in projects, as ComLab-2 and InFiRo etc.

1. Introduction

School is an institution, where the knowledge and skills are deliberately planned and professionally transferred to the target group, although the knowledge cannot be accepted without effort. Teachers cannot force anyone to »spend« the time by such learning, they can only establish the same opportunities for quality education of these, who feel the needs to gain, revise or supplement the knowledge, skills and experience in all ages, regardless of sex, race, education background and abilities.

School should pay special attention to the gifted students, who are the force of development of today's world. Without them and their inventions, many useful and practical things would not be invented. Even more, we may not know the computer and modern information communication technologies.

2. Related work

2. 1. State of work in the field of efforts with gifted students

Slovenian educational system settled fairly good benefits for the youngsters with special needs, who need more time and special methods in order to gain the knowledge. Furthermore, we want them to be equally integrated just as their peers into the regular educational process.

On the other hand, the completely different situation is with the gifted students, who would also need special approach or additional resources and time to upgrade already high level of the knowledge. Standards, rule books and other obligatory files barely touch the topics about gifted students, even though we could consider them also as youth with special needs.

Primary education have taken care about work with gifted students since 1999, when the Professional body for education accepted the document called Perception and work with gifted students. Real educational process started with the work a year or two later. Education of gifted students follows the Act in primary school. The schools need to percept and identify gifted students and it is obligatory to prepare methods and work programme for each gifted pupil in the form of additional individual or team work [1].

Such work is interrupted after entering the secondary educational process. Systematically and planned concept of working in education with gifted students in secondary schools started in Slovenia in 2007/08, when five gymnasiums and five technical-vocational schools were chosen among 32 applications in public tender. Selected schools were piloting the concept of work with gifted students monitored by the National Educational Institute [2].

Project results are shown in the change of the Rule book of norms and standards for educational programmes in secondary schools. From school year 2011/12, the teachers who work with gifted students have 9 hours per students per year acknowledged as additional work.

Actually, whenever calculation of working hours with gifted students appears in correlation with costs, principals and teachers' enthusiasm usually disappears.

2. 2. Experts' opinion about gifted students

Even though there has been no common definition of talent, the most general experts` opinion is that we can talk about talent, when the individual has the ability and skills to achieve superior results. In general there have been differences between a gift as the ability to achieve superior results on various fields and a talent, as the ability to achieve superior results on one field.

Experts recognise different forms of gifts. A curious reader can find positive and negative features of gifted students in different scientific papers [3, 4, 5]. The papers often quote the fact that gifted students need to face extra challenges in order to develop completely their potential, otherwise they get bored, dissatisfied and annoying for educational process [6].

Experts generally agree that gift as it does not necessary mean, that individual will achieve special results. Not only gift, but also creativity, motivation and simulative environment are necessary (Fig. 1.) [7].

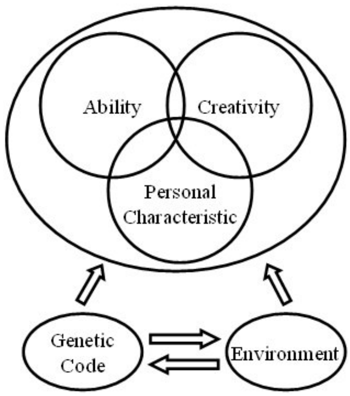

Fig. 1. Gift in image and word - five level concept

2. 3. Basics, which were followed

General concept of perception and work with gifted students anticipate recording of the persons, who could be gifted, identification of the gift done by creativity and ability scales or tests and work with gifted students [7].

Independently of the concept, the decision about engagement of each individual into extra activities, besides of school process, was made. The gifted student is free to decide about doing additional two to four hours per week of extra activities, half of them as individual work. Extra energy and resources has been and will be invested in each student, who wants more. We believe that gift is much more than an excellent school grade or reproduction or learned contents.

Work with gifted students is set according the following criteria:

- Establishing the atmosphere, where student would feel comfortable, enjoy the activity, and gladly come back to school as the one, who desire the knowledge or give it.

- Variety of extra activities, which would provide enough opportunities, possibilities, skills and experiences for positive influence on youth professional and personal development.
- Voluntary cooperation.
- Creation of possibilities, in which teenager can partly or completely use the extra activities within regular educational process.
- Active cooperation of student in planning, performing and promoting of selected activity.

2. 4. Introducing extra challenge into gifted student's life

Vigotsky and others explain the fulfilment of the following conditions for the optimal development of a teenager [8, 9, 10]:

- Every teenager should comprehend the topics with extra help;
- Help and cooperation should be delivered in an appropriate way;
- Taught/learned topics should be on the adequately higher level;
- Appropriate living environment quality out of the school should be ensured.

Vigotski shares the opinion about teachers` important role in the educational process of gaining new knowledge (environmental influence on child). Most conditions for optimal education and training are namely defined by teachers [8, 9, 10].

After the analysis focused on the possibilities offered to the teenagers, we decided to offer the challenge to behavioural troublesome gifted students in experiential research – research, also production planning and marketing, as well as participation in competition of young researches.

In the researches the students dealt with the didactic tool eProDas-Rob1, designed during EU programme Leonardo da Vinci named ComLab-2 coordinated by University of Ljubljana, Faculty of Education [11] (Fig . 2.). the tool was later upgraded according to hardware and software support within Leonardo da Vinci transfer of innovation project InFiRo.

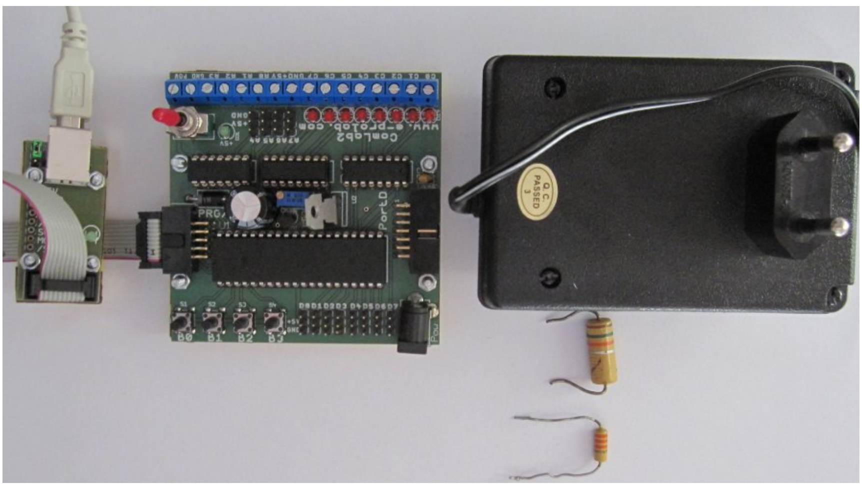

Fig. 2. Didactic tool eProDas-Rob1 and add on

Satisfaction of the students was estimated through the interview on the scale from 1 (very unsatisfied) to 10 (very satisfied). Student`s success was valued with grades from 1 (insufficient) to 5 (excellent) due to the difference between given and completed work.

The influence of research work on the gifted student will be shown on the case of three students in study year 2012/13, which have different interests, but strong desire to prove themselves.

3. Case studies

We have been monitoring and comparing the independence, satisfaction and success at the beginning and at the end of the one year work. The satisfaction was evaluated by the scale from 1 (not satisfied) to 10 (extremely satisfied).

3. 1. Case study no. 1

Starting condition

Student was educated in the field of computing. He wanted to gain new knowledge in professional subjects and put the effort and time into it. He was especially interested in database and their practical usage. Students evaluated his satisfaction with the grade 6. The general school success was very good (grade B). He was getting bored during the classes and he accepted the advice for the set problems through the questions.

Working process with the student

The student accepted the challenge to upgrade the didactic tool EproDas-Rob1 with hardware and software into the automatic voltmeter model. The model can be distance managed; even it is in the stage of automatic working modus. Software, accessible on the Internet, enables saving, analysis and collected data display.

Student had the possibility of extra meetings and work on the module. Counselling and consultations were led through e-communication tool Skype. From the beginning the student used the help three to four times per week, later approximately two hours per week (Fig. 3). The quality of work raised by the time of cooperation. Extra hours of help were occasionally also used by schoolmates.

Results

Student, who attended the Young Researcher Competition in the frame of the mentioned project, gained the silver medal on national level. Another student of the field of mechatronics helped him with the electronic elements. The project was also used in final exam, called Matura.

He finished the school year with the excellent success and evaluated the satisfaction with the grade 10. The possible questions were focused into solving the new problems. The student didn`t ask for the solution, but for the advice, especially in searching the sources, literature and information for independent problem solvation. His schoolmates constantly asked him for help and explanation on the professional level.

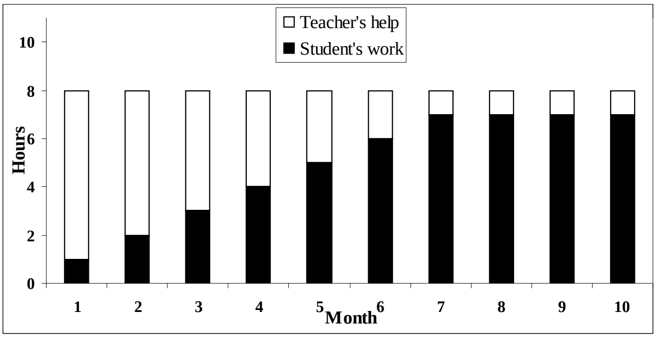

Fig. 3. Ratio of teacher`s help and student`s work input in successfully finished activities – case study 1

3. 2. Case study no. 2

Starting condition

The student was educated in the field of Mechatronics. The general school success was very good (grade B). The student was very disruptive during the lessons due to his higher expectations in problem discussion from different point of views, but on the level too high for the classmates. As the result of such discussions the arguments with some teachers appeared as they were treated as provocation. He mentioned the school weakness of not giving special attention to students, who want more knowledge.

He invested a lot of effort and time into the field of mechatronics complex planning and programming. He acted independently and evaluated his satisfaction with the grade 6.

Working process with the student

The student accepted the challenge to upgrade the didactic tool EproDas-Rob1 with hardware and software into the system, which is designed for searching the casualties in the labyrinth. We mostly communicated through e-mail and the system for the lesson managing called Moodle. In comparing with other students, he was offered to solve tasks of higher level and adjusted to his knowledge. He didn`t need an extra help and he mostly cooperated with the mentor in solution analysis (Fig. 4).

After three-month work and competition of robotic success, the interest was shown to participate in the Young Research Competition. The project was also the part of the final exam, called Matura. Because of the student`s extra autonomy, the teacher`s task was focused into new problems task search and guiding him into new paths for solutions. Even though the possibility of using ICT and dealing with tasks of higher level, the students didn`t take this opportunity.

Results

After three-year work with the student, he started to make plans with the teachers for extra cooperation and evaluation system. The arguments with the teachers almost disappeared or where solved in a very constructive way. He finished the education with the best success (grade A). Student participated the Young Researcher Competition and gained the silver medal on national level. He evaluated the satisfaction with the grade 10. The student made connections with the companies with the offer of commercially oriented solutions on the market. The teachers agreed that the possibility with company cooperation is great but the absence in lessons mean also the lack of the experience for the other students.

The student cooperated with the faculty students in robot planning and preparing for the Mobile Robots Competition, which was organised in May 2012 in Austria.

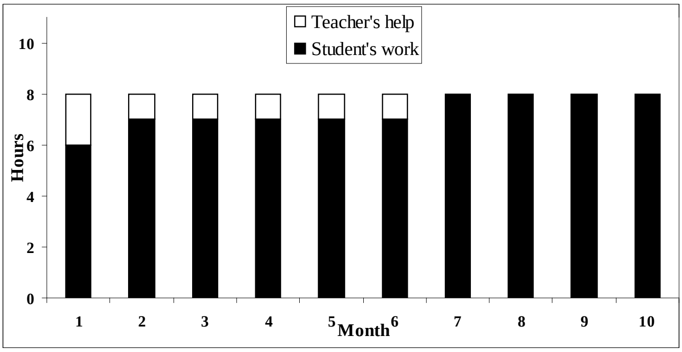

Fig. 4. Ratio of teacher`s help and student`s work input in successfully finished activities – case study 2

Case study no. 3

Starting condition

The student was educated in the field of computing. Initially, he was not interested at the field of technics and he was a disruptive person at the beginning. The general school success was very good (grade B). He evaluated his satisfaction with the grade 6.

Working process with the student

The student was offered the participation in the project » Information support of RFID system« on the base of didactic tool EproDas-Rob1. We mostly communicated through e-mail and the meetings. The student work very autonomous but with no interest (Fig. 5). He regularly attended the meetings. He didn`t show any interest for the Young Research Competition.

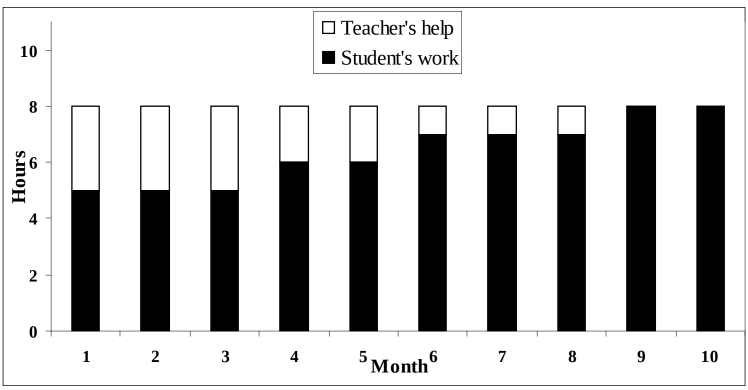

Fig. 5. Ratio of teacher`s help and student`s work input in successfully finished activities – case study 3

Results

Regardless to his restrains at the beginning, he participated the Young Research Competition and won the silver medal on national level. His satisfaction raised to grade 9. He finished the school with the great success (grade A). The project was used in final exam, called Matura.

4. Conclusions

Students show great dissatisfaction if learning challenge is not adjusted to their temporary knowledge. This is especially big problem with gifted students, who easily notice a big difference between syllabus and their own requirements. If condition of dissatisfaction lasts too long, the behavioural patterns appear: lack of self-confidence, disability of teamwork, emotional and social immaturity, low self-esteem, good grade, is not motivational. Mentioned and similar patterns can hinder the student and a teacher in normal school working process.

Research shows, that individual study work with gifted students can be of a great help, especially if satisfying the appropriate planning and monitoring suitable for each individual. Theory findings and study cases lead to the conclusion that mentioned behavioural patterns can disappear if adequate approach for work with gifted students is implemented. Students are more satisfied, more independent, and more communicative and have better self-esteem, because their individual research work enables self-affirmation.

Such activities are still underestimated in Slovenian education and are based on the enthusiasm of individuals. Continuity of work with gifted students is still in beginning, what puts teachers into a delicate position. Legislative nine hours per student per year is just a drop into an ocean considering actually spent working hours. Therefore, work with gifted students presents a lifestyle of a teacher, not only a job; otherwise one cannot manage the continuity of work with such students.

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InFiRo-Xplained board

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The article is describing educational InFiRo-Xplained board, which was designed to be used in robotics education and also useful for data acquisition at science lectures. The interface is modularly designed with XMEGA-A1 Xplained board used as a base which has a lot of great features that are presented in paper. In addition the base board is equipped with InFiRo-Xplained module which includes some extra power terminals, high current outputs, servo-motors like connectors, screw terminals for additional wiring with other sensors, motors and peripherals. Furthermore some "getting started" examples of programming the interface are presented with some more description on software support and its features. Since the interface can be used for measurements of physical quantities as well, the illustrative example on evaporating heat detection is described as an example of science education. The article also stresses yet unused potentials of the interface in particular, sampling rate, which ranks the interface side by side with the professional equipment.

1. Introduction

Since introducing robotics in education is very popular, we have experienced a little boom of controlling interfaces all over the world. Although they are very different at the first glance, their operation is very similar, if not identical indeed. Basically they are all constructed around one microcontroller with 8-, 16-, or 32-bit architecture [1]. However, we can quickly notice that these interfaces are mostly used for the purposes of robotics and similar activities where arouse young people's interest and reap great educational achievements [2]. (reading sensors responses and controlling the motors) which is far from exploiting their didactic potential. These same devices could also be used in physics, biology, and chemistry classes in order to carry out measurements of quantities in various experiments instead of using an expensive data loggers and data acquisition systems such as LabQuest [3] interface form Vernier. The real data experiments are very important from educational point of view to follow the modern didactic guidelines such as problem-based, inquiry-based learning or learning by doing. Those approaches filling the gap between the education and real life experiences and also increases technological literacy [4]. Therefore, our intention was to develop such an interface, which could be used in teaching robotics as well as for the purposes of measuring data in science classes.

2. Hardware development

At first stage of developing such an interface, we were asking ourselves where to start: should be board designed as stand-alone or modular board should be developed as completely new board or to be an extension of an existing board. However after a review of some existing boards' features we must outline some strong points of them: on-board breadboard to constructing the additional circuits on Parallax Board Of Education – USB [5], huge community using Arduino UNO board [6], low price of Chinese replica of Arduino – called Funduino UNO, nice "all-in-one package" on board eProDas-Rob1 [7], easy to use plug-and-play like interface from Lego NXT [8], excellent compromise between educational and prototyping features in ROBO TX interface [9] and huge opportunities offered by Linux operating system running on Raspberry Pi [9]. Taking into the consideration that this interface should be also used in science lectures for data acquisition we end up with XMEGA-A1 Xplained board [11]. In that relation we must point out on-board 8MB external sdram, the analogue data are sampled in 12-bit resolution and its maximum sample rate can be up to 2 mega samples per second, which is the fastest sample rate by far in that rank.

XMEGA-A1 Xplained board also comes with other on-board features that can be used right away. The users can start programming, testing and experimenting with some devices (as presented in Fig. 1) like: on board keys, light sensor (with photo-transistor), temperature sensor (with ntc resistor), DAC with on board speaker and external SDRAM even before they had to connect or construct something to the board.

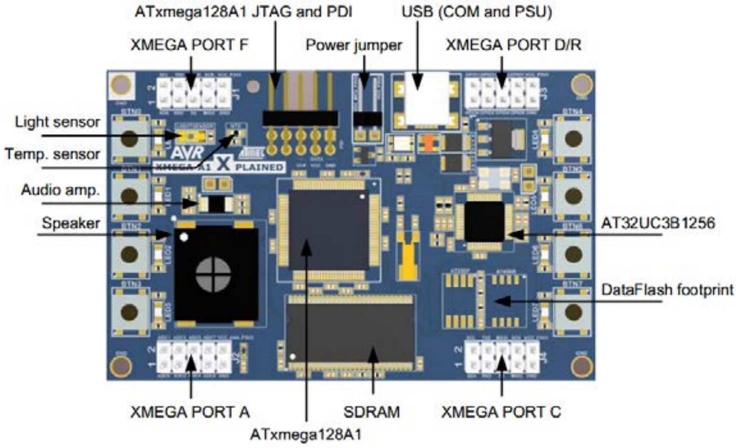

Fig. 1. Overview of the XMEGA-A1 Xplained board [9].

For further developing with the XMEGA-A1 Xplained board several modules [12] and sensors [13] can be attached to its additional 4 10-bits connectors (PortA, PortC, PortD/R and PortF) with 32 i/o pinouts in total. However we develop two more modules with Xplained footprint. First is ordinary breadboard (see left side of Fig. 2) with mentioned footprint and is appropriate for constructing of our own circuits. The second is INFIRO board (see right side of Fig. 2) which in more sophisticated with the aim of use in robotics education.

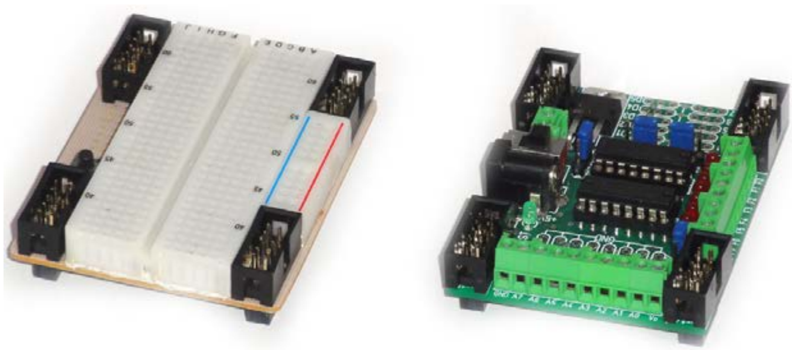

Fig. 2. Additional breadboard (left) and INFIRO board (right) for ATMEL's Xplained boards.

Since those boards are designed to have female-male terminals from bottom side to top side of the board they can be merge into a “sandwich” form with a several of them.

2.1 INFIRO-Xplained board

The INFIRO-Xplained board is an interface with general characteristics required for introducing robotics to education. On the board, we can find next features (arranged according to Fig. 3):

- 8-bit digital high-current outputs accessed via screw terminals signed from F0 .. F7. Each bit is also equipped with LED which represents logical state.
- 6 TTL compatible digital outputs or inputs from PortD, which are arranged with power and ground line into a 3-pins connector.
- 6 TTL compatible digital outputs or inputs from PortC, which are arranged with power and ground line into a 3-pins connector.
- 8 analogue inputs with 12-bit resolution. All inputs can be connected via screw terminals from A0.. A7 or via 3-pins connector with similar signs.
- 2 low current analogue output with 12-bit resolution. This functionality can be accessed via screw terminals A2 and A3 in range of 0 - 5 V or via 3-pins connector A2 and A3 in range of 0 - 1 V.
- All 3-pins connectors has closable power supply between 3.3 V or 5.0 V for all pins on the same port.
- Power supply of the board can be provided by three different possibilities with their strengths and weaknesses:
    - Powering the board with 3.5 mm jack plug is the default option since it is suitable in first stage of programming and testing our project or even in future operations of a device that is not meant to be mobile. In this case the maximum supply voltage is 18 V (this is also the output voltage of PortF high-current pins) and the maximum current is limited to 3 A.
    - For mobile devices is more suitable to power them with batteries and INFIRO-Xplained board can be powered thru screw terminal which are signed with " +" and " - " marks. The maximum ratings are the same as in the jack powering case.
    - Powering the board from computer's USB plug can also be used. In that case we must be aware that the maximum consumption current is 500 mA and the output voltage is 5 V.

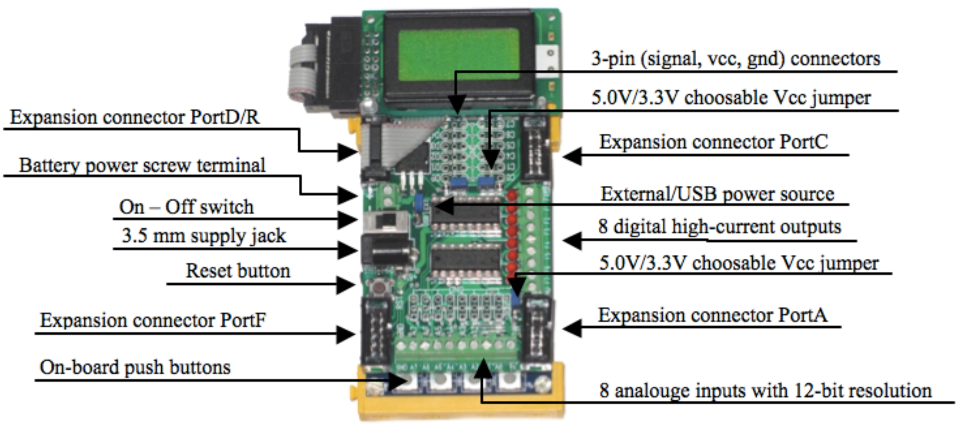

Fig. 3. InFiRo-Xplained interface.

3 Software support

In order to use this educational interface in primary schools the handling with it should be as simple as possible but on the other hand not too far away from understanding of basic operations of the interface. In that sake we have written some new functions, with which we believe that the InFiRo-Xplained interface is even more useful in educational area.

3.1 Bootloader

XMEGA-A1 Xplained board comes with its own bootloader called BatchISP and can be downloaded from the web. In general, it works well, but bootloader included in BASCOM-AVR programming environment called MCS Bootloader [14] is much faster but it does not allow to changing the fuse bits in contrary to BatchISP bootloader. Since we are working with BASCOM-AVR to programming the AVR microcontrollers we had chosen the MCS Bootloader, which we have had upgraded with on-line support and enabled communication via UART0 or UATR1 on PortC.

The on-line functions in bootloader are very convenient because we do not need to program the interface every time we want to test the connections of peripherals. The set of these functions is small and very basic nature like setting or reading any microcontroller's register or waiting some bit to be cleared or set before executing the next command. This simplicity allows the user to create his own on-line functions and to take advantage of xmega architecture like Timers, ADC, DAC, DMA …

3.2 On-line programming

Although this interface is meant to be used in off-line mode for controlling mobile robots the off-line mode can be handy to, especially in first stage of programming when we are testing the connections of peripherals or to controlling the robot with a benefits of using the computer's opportunities as well. This connection can be done via USB cable where the interface is detected as "Xplained Virtual COM port" or via microcontroller's UART 1 connectors on PortC. Since the UART is very settled communication is presented in several devices like Bluetooth, Radio-transivers and WiFi modules, the on-line communication can be established via those technologies by devices like computers, smartphones or tablets.

3.2.1 Visual Basic on-line programming example

During the InFiRo project, we have written programming object called Xplained_A1 which can be used in Visual Basic (VB) programming environment. The libraries can be downloaded from the web [15] in zip file form. In it we can find two files: "Xmega128A1.vb" contains all the addresses of the Xmega128A1 microcontroller and in "Xplained_A1.vb" we can find the Xplained_A1 programming object with all its useful functions which can be used to program the InFiRo-Xplained board. Functions are also well supported with theirs help what is very important in very first steps of programming. In Object Browser of a VB programming environment, we can see full documentation of specific function while the specific help of the function is shown when we are entering function's code. In Fig. 4. we can see both two descriptions of OnLineMode function.

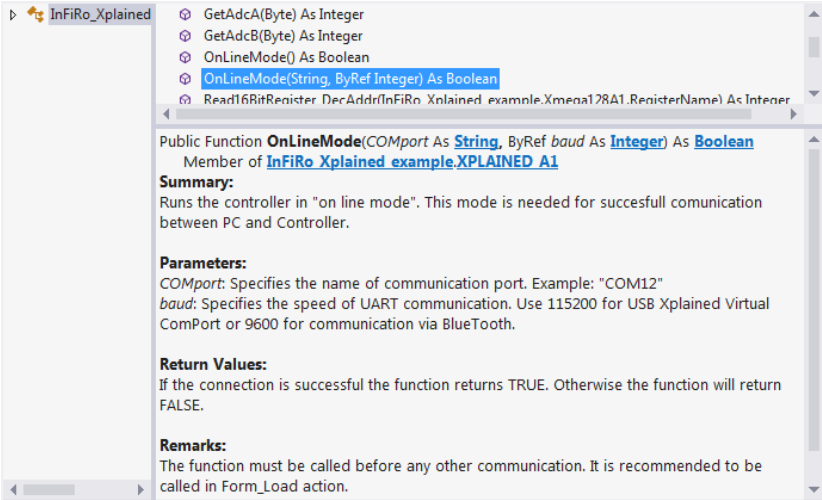

Fig. 4. Object Browser with function description on left and specific help of the function meanwhile programming on right.

Next "getting started" example shows a simple stand alone application (left side of Fig. 5) and its code to control InFiRo-Xplained board via on-line communication in VB programming environment. After starting "New Project..." we must include mentioned files Xmega128A1.vb and Xplained_A1.vb into it. With programming code shown on Fig. 5 we first create new object XPLAINED_A1 and then start communication with our interface.

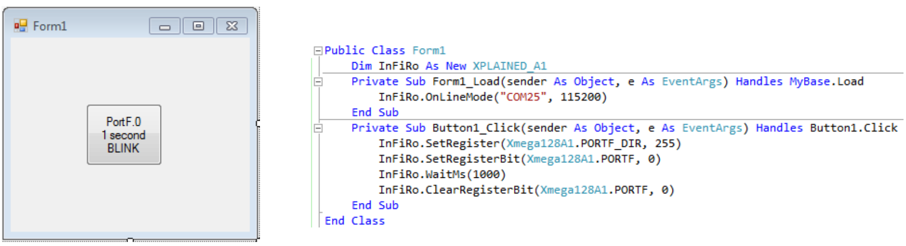

Fig. 5. On-line program (left) and its programming code (right).

3.3 Off-line programming

In most of cases, the InFiRo-Xplained interface will be used as autonomous controlling device for controlling rather small mobile robots that are very popular now days. In such situation, the InFiRo-Xplained interface can be used in off-line mode, meaning that the interface must be plugged or connected via Bluetooth connection with a computer only for up-loading the program. Since the program is successfully uploaded the interface can be disconnected from a computer and it operates autonomously according to uploaded program. In order to program the InFiRo-Xplained interface we can use any programming environment that is suitable for AVR microcontrollers many of them are freely available like: Atmel Studio [16], Eclipse with AVR Plugin [17] (Windows, Mac and Linux support), mikroPascal-AVR [18] (fully functional demo license with up to 4096 bytes), BASCOM-AVR [19] (fully functional demo license with up to 4096 bytes) ...

3.3.1 BACOM-AVR off-line programming example

Since the BASCOM-AVR is using basic programming language and its structure is very similar to code in Visual Basic programming environment we recommend that program to go with. Although the BASCOM-AVR is not completely free, but its demo version can generate up to 4096 bytes of machine code what should be enough for educational purposes. Examples on the left side of Fig. 6 show some code written in mentioned environment with the same purpose as demonstrated in VB example and similarity of the code can be easily spotted.

In addition, also a library A1_Xmega_xplained.LBX for BASCOM-AVR was written to simplify the use of XMEGA architecture that is a bit more complex according to ordinary 8-bit AVR microcontrollers. Example on the right side of a Fig. 6 shows a simple use of these functions for reading analogue input on channel 6, instead of using original commands (middle side of Fig. 6) to control the XMEGA ADC peripheral.

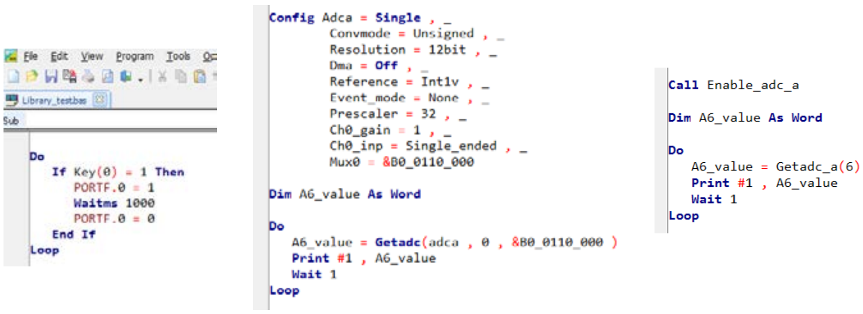

Fig. 6. Of-line programming the InFiRo-Xplained board in BASCOM-AVR

3.4. Data Acquisition System

Such devices that are used to controlling the robots and sensing the surroundings can be easily used also in physics classes to measure physical quantities such as distance, velocity, acceleration, temperature … Those data – measured in the experiment right in front of the students – can be of a great help to the teacher with interpretation of a theory. In order to have that possibility, we also prepared some examples on how the InFiRo-Xplaine interface can be used to measure some simple data. In Fig. 7 is shown the simple connection of ntc thermistor in order to measure temperature. In the same Fig. 7 two responses of that sensor are shown which are presented in open source program Serial Osciloscope [21]. On the right chart, we touched temperature sensor with dry fingers, while on the left side the fingers was wet.

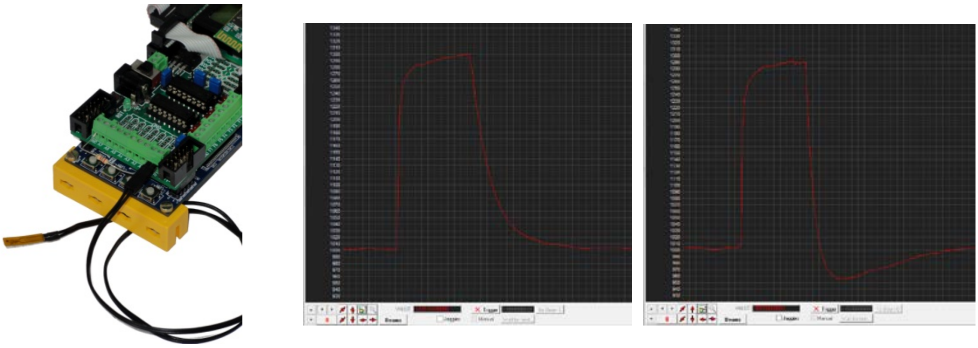

Fig. 7. Constructed simple temperature sensor (left) and its responses of heating and cooling in dry and wet conditions.

The outcome is interesting in comparing the situation when we released the temperature sensor. In the first chart the curve is normal as it should be according to Newton's law of cooling. However, in the second chart we can easily notice that the cooling process is much quicker and even undercooled itself compared to surrounding temperature. In that case, also the evaporation, heat needed to evaporate the moister on the sensor, must be taken into the consideration. Such real data experiments can be great opportunities for inquiry-based learning for students.

4. Results and conclusions

After a few tests (some of them was also presented in paper), the InFiRo-Xplained interface promises good results. The on-line communication is really a step forward in comparison with eProDas-Rob1 interface. The functions for Visual Basic programming environment are much easier to use and the ability to communicate via Bluetooth connection opens up a new possibilities for the use of the interface.

Since the interface can be used in science classes some simple measurements can be done but a teacher or students must further process the data. In order to measure the physical quantities we still did not yet used all strengths of the interface. In particular, we should note the maximum sampling rate which can be 2 million samples per second in full 12-bit resolution (sampling only one channel) with which the interface can be placed at the side with the capabilities of a professional data acquisition devices (mentioned in paper) or even beyond.

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Building a mini-sumo robot

University of Karabuk, Faculty of Technology (P4),
Transferring, Adopting and Developing Software (WP5)

The objective of this study is to design, build and test an autonomous mini-sumo robot, which will participate in Mini-Sumo Robot Competition. This robot project has three subsystems: mechanical, software and electrical. This report deals with the design approach, block diagram, and theory of operations, specifications, and procedure followed to make the mini sumo robot, which is successful.

1. Introduction

Mini-sumo robot is a robotic version of one of Japan's most popular sports, sumo in Fig. 1. Mini-sumo robots are small autonomous mobile robots designed specifically for sumo style competition. Bill Harrison of SineRobotics invented the mini-sumo class. Except for the weight of the robot, every other specification is exactly half of the international sumo class. Unlike larger battle robots, mini-sumo robots are not allowed to damage the opponent robot, they are only allowed to push it off the dohyo. There are three bouts per match, and a robot must win two out of three bouts to win a match. All three bouts must be completed in a three-minute time frame. The main components of a mini-sumo are a body frame, motors, wheels, microcontroller, sensors, and batteries. Sensors are used to detect the opponent robot and base. The robot control is realized with microcontrollers. All the hardware components you will need to build the robot are discussed in this study. A mini-sumo robot can be assembled in a few hours or less. Once you have assembled your robot, you can load the mini-sumo example program included with the software and have your robot ready for its first competition in just minutes. Once you have your robot up and running, the well-documented example source code, the extensive robotics class library, and the easy to use integrated development environment will make improving your robot's intelligence and competitiveness a snap [1].

2. Mini-Sumo Robot Competition

The mini-sumo robot competition rules restrict the robot length and width to 10 cm x 10 cm, but do not restrict its height. In addition, the robot cannot weigh more than 500 grams. The size specifications of the robots only apply at the beginning of a competition round. Table 1 lists the specifications for mini-sumo robot. Once the round has started, the robot can expand in size as long as its weight does not exceed the maximum, and all parts of the robot must remain attached together. This rule allows for some interesting design options. For example, a robot can have a pair of arms that deploy sideways to try to help capture its opponent. Since there is no height limitation, robots can have very long arms.

According to the rules, sumo robots must move continuously. Another rule states that the robot cannot be sucked down or stick to the sumo ring. This particular rule has resulted in many different interpretations. Basically, what it means is that builders cannot use any adhesives to "glue" the robot to the surface of the ring, or use a vacuum suction cup to "suck" it to the ring. A literal interpretation of this rule states that if a robot is "glued" or vacuum-sucked onto the ring, then the robot is no longer moving continuously and will thus automatically lose. But what if the robot can still move, despite being "glued" down? Because of the "continuous move" rule, some robots use vacuum systems to help pull the robot down to the sumo ring, and use sticky substances on the tires to increase traction. As long as these methods allow the robot to continuously move, and do not damage (or leave a residue on) the sumo ring, they are allowed. Some robot sumo contests have very specific rules that prohibit the use of sticky wheels and vacuum systems [2].

Fig. 1. Sumo Wrestling.

Table 1. Mini-Sumo Robot Specifications.

	Mini Sumo Class
Length	10cm
Width	10cm
Height	Unlimited
Mass (maximum)	500g
Sumo Ring Diameter	77cm
Border Ring	2.5cm

2.1. Mini-Sumo Robot Competition Rules

Competition rules are itemized below:

- Jamming devices, such as IR LEDs intended to saturate the opponents IR sensors, are not allowed.
- Parts that could break or damage the ring are not allowed. Do not use parts that are intended to damage the opponent's robot or its operator. Normal pushes and bangs are not considered as intent to damage.
- Devices that can store liquid, powder, gas or other substances for throwing at the opponent are not allowed.
- Any flaming devices are not allowed.
- Devices that throw things at your opponent are not allowed.
- Sticky substances to improve traction are not allowed. Tires and other components of

the robot must be in contact with the ring.

- Devices to increase down force, such as a vacuum pumps and magnets are not allowed.

2.2. Mini-Sumo Ring Specification

The mini-sumo ring is basically a large, smooth, flat disk made from solid black vinyl. Obtaining a 77cm-diameter piece of vinyl is often very difficult, so most mini-sumo rings are made out of regular plywood. Fig. 2. shows a drawing of the mini-sumo ring. The sumo ring can be made out of virtually anything as long as the overall dimensions are maintained. Most mini-sumo rings are made out of plywood. For a mini-sumo ring, a 1-inch-thick piece of plywood will work [3].

3. Mini-Sumo Robot Design

The robot's design specifications vary per organizer's requirements. The design specifications of the robot are divided into the following mechanical, software and electrical subsystems: microcontroller, object and light sensors, and motor.

3.1. Mechanical Design

The body of the robot is square shaped with two wedged shaped protuberance on front and back of the robot, which is about 10 cm wide and 10 cm long and 5 cm high. The circuit board is implemented in the middle of the square. There are two DC motors controlling each wheel, where the motors again will be controlled by the microcontroller. The wedge shaped geometry was selected because we have the option of flipping the opponent, plus it gives the electronics better protection, given its dimensions. Furthermore, it makes the attacker have a hard time damaging the interior. The wedged shape geometry allows quick manoeuvrability and stability, which is desirable for robotics competition. Fig. 3. shows our mini-sumo robot's mechanical design.

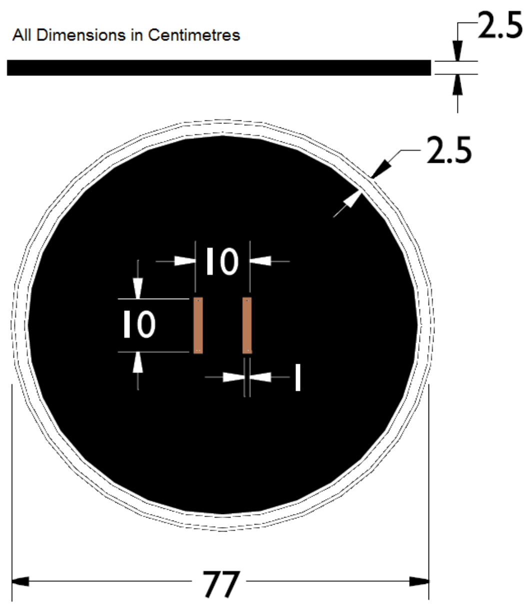


Fig. 2. Mini-Sumo Ring.

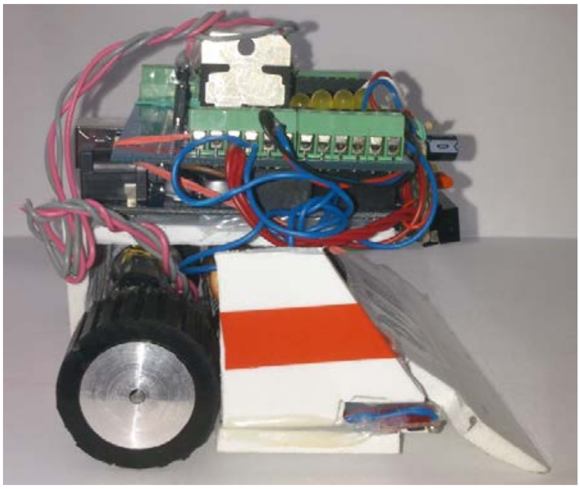


Fig. 3. Mini-Sumo Robot's Mechanical Design.

3.2.. Electronic Hardware

The mini-sumo robot's electronic hardware is designed based upon the block diagram in Fig. 4. The main part of the body is the microcontroller. This microcontroller is the brain of the robot which executes the stored program based upon the voltage input coming from the object and line sensors. If the object sensors are active then the microcontroller signals the motor to move towards the object. If the line sensors are active then the microcontroller signals the motor to move away from the line by rotation in a certain angle [4].

3.2.1. Sensing the Dohyo Edge

The mini-sumo robot relies on two ORB1134 infrared photo-reflectors to detect the white edge of the dohyo. These sensors are mounted at the left and right front corners of the robot, facing the surface of the dohyo. The sensors generate a low voltage output (~.2 volts) over the highly reflective white edge and a higher voltage output (~4.8 volts) when over the less reflective black centre of the dohyo. According to the output voltage of the sensors, the software can determine if the robot is at the edge of the dohyo. Fig. 5 shows line sensor [5].

3.2.2. Sensing the Opponent

Two Sharp GP2D12 infrared range sensors are used to sense and target the opponent. These sensors are mounted on the left and right front of the robot, facing forward. Similar to the line sensors, they output an analogue voltage. The voltage is higher the closer the sensor is to an object. The sensor outputs approximately 2.5 volts when an object is 10 centimeters away and 0.4 volts when an object is 80 centimeters away. The sensor is not effective outside of this range. The sensor is more precise at the shorter distance end of the effective range. Fig. 6 shows range sensor [6].

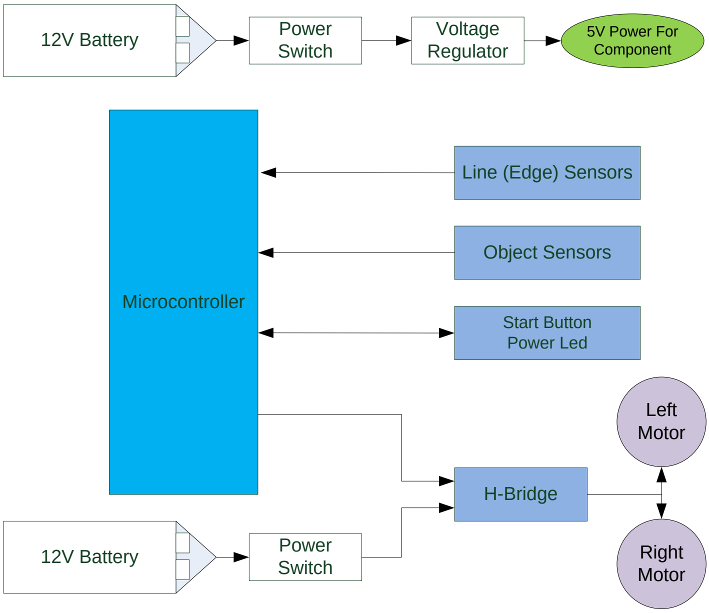


Fig. 4. Mini-Sumo Robot's Electronic Hardware.

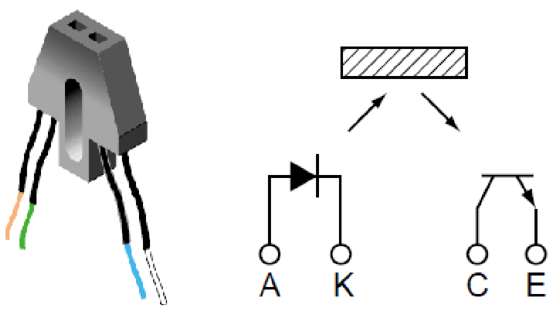
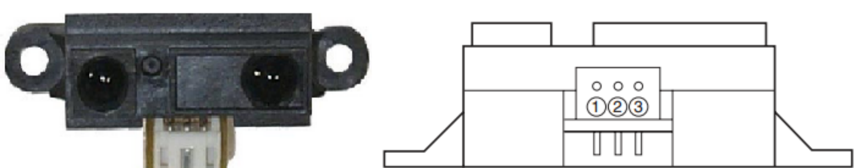


Fig. 5. Line Sensor.



PIN	SIGNAL NAME
①	V_O
②	GND
③	V_{CC}

Fig. 6. Range Sensor.

3.2.3. DC Motors

Two 12V DC motors attached to the two wheels provide the mechanism to move the robot. Steering is accomplished by rotating the wheels at different speeds. When one wheel turns slower than the other, the robot will move in an arc curving to the side of the slower turning wheel. By turning the wheels in the opposite direction of each other, the robot will rotate in place. Motors are controlled by microcontroller via H-Bridge motor driver. LMD18200 which is H-bridge motor driver integrated circuits (ICs) is used in our mini-sumo robot. LMD18200 uses pulse-width modulation (PWM) signal to vary the motor speed, which can give you better speed, braking, and direction control resolution. Fig. 7. shows DC Motor and LMD18200 motor driver circuit [7].

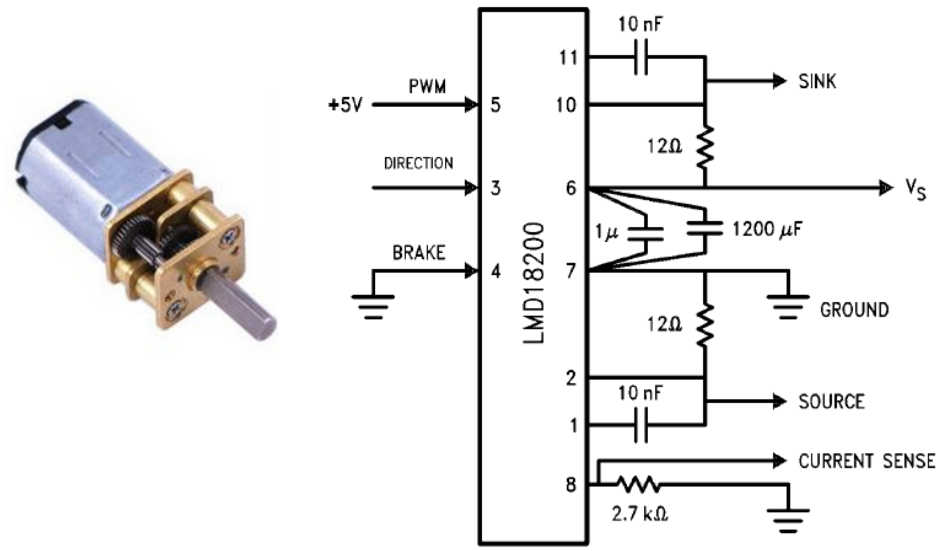


Fig. 7. DC Motor and LMD18200 Motor Driver Circuit.

3.2.4. Microcontroller

The main component of an autonomous mini sumo is the microcontroller that is used for the robot's brain. Microcontroller controls the robot's behaviour by software written in it. Software implements the robot's intelligence, linking its behaviour to the data it collects from its surroundings via sensors. The most important feature of microcontroller is that it consumes less power. This is very important feature because during the competition the robot has to run for long time, which requires a lot of power. Low power consumption feature will help to save power during the competition. Atmel AVR, Microchip PIC or Arduino Board can be chosen as microcontroller of mini-sumo robot. Arduino Uno microcontroller board is chosen in our mini-sumo. Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started [8]. Fig. 8. shows Arduino Uno microcontroller board.

3.3. Mini-Sumo Software

Once you have constructed your mini-sumo robot you must download autonomous mini-sumo software to the robot. The mini-sumo software has been implemented in Arduino software. If you have experience with C, C++ or another high-level programming language, understanding to the mini-sumo programming should not be difficult. The flowchart of program is shown in Fig. 9.

After programming, place the robot on a mini-sumo dohyo, power it on and press the start button. When you release the button the robot will begin its five-second countdown, as required by the mini-sumo rules. Once the countdown is complete it will start moving. If everything is working correctly, the robot will wander around the dohyo in an arcing pattern and spin around each time it reaches the edge of the dohyo. If you place an object similar in size to the robot on the dohyo, the robot will find it and push it off the dohyo [9].

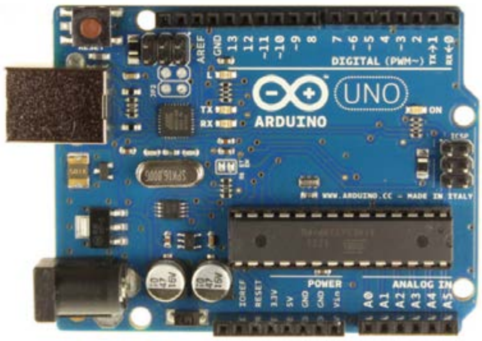


Fig. 8. Arduino Uno Microcontroller Board.

4. Testing the Mini-Sumo Robot

After the whole body of the robot is assembled, every component as well as the overall robot is tested. The test was done in three levels. In the first level each and every component were tested individually for its proper functioning. For example, applying simple commands tests the microcontroller, the motors were tested by directly supplying the voltage source before interfacing it with the microcontroller, and sensors were also tested by supplying the separate power supply. The second level of testing is done when the components are assembled and interfaced along with the microcontroller, which is loaded with the desired software code. During this testing phase, coding errors are also debugged. The last level of testing is done on the final project, which is the built robot. This level is done to verify that the robot meets the competition specification and it is reliable to compete in different battles.

5. Enhancing the Mini-Sumo Robot

The example application presented here implements a fairly simple control algorithm. There are many alternatives you may experiment with to improve your robot's competitiveness. The following list includes some ideas on how to improve your robot:

- Tune the control constants to enhance the robot's performance
- Improve the aiming in the targeting state
- Add steering in the attack state

- Add more sensors to detect the opponent from any direction
- Add sensors to sense being pushed backward off the dohyo
- Add shaft encoders to sense and better control the robot's motion
- Add different types of sensors such as sonar
- Add new states such as escaping when being pushed by the opponent
- Implement a behaviour system using the Behaviour Arbiter class experiment with new motion algorithms in the existing states
- Randomize the behaviour of the robot to make the robot less susceptible to weaknesses of a particular behaviour
- Use multi-threading to execute portions of the control software concurrently, for example, sampling sensors at the same time as executing manoeuvres

6. Conclusion

In brief, the objective of the study is to design a mini-sumo robot that will compete in the annual mini sumo robot competition. This robot project has three subsystems: electrical, software and mechanical. The robot is double-sided wedge shaped. The inner design will have microcontroller, reflective object sensors, and motor. The major difficulty was in the software integration to the hardware. Overall the project was successful; however, there are still many improvements that can be made such as the efficient use of the many unused outputs of the microcontroller to make the robot respond at faster rate, and have more speed to it. Higher intelligence can also be implemented to the robot via extra unused ports in the future.

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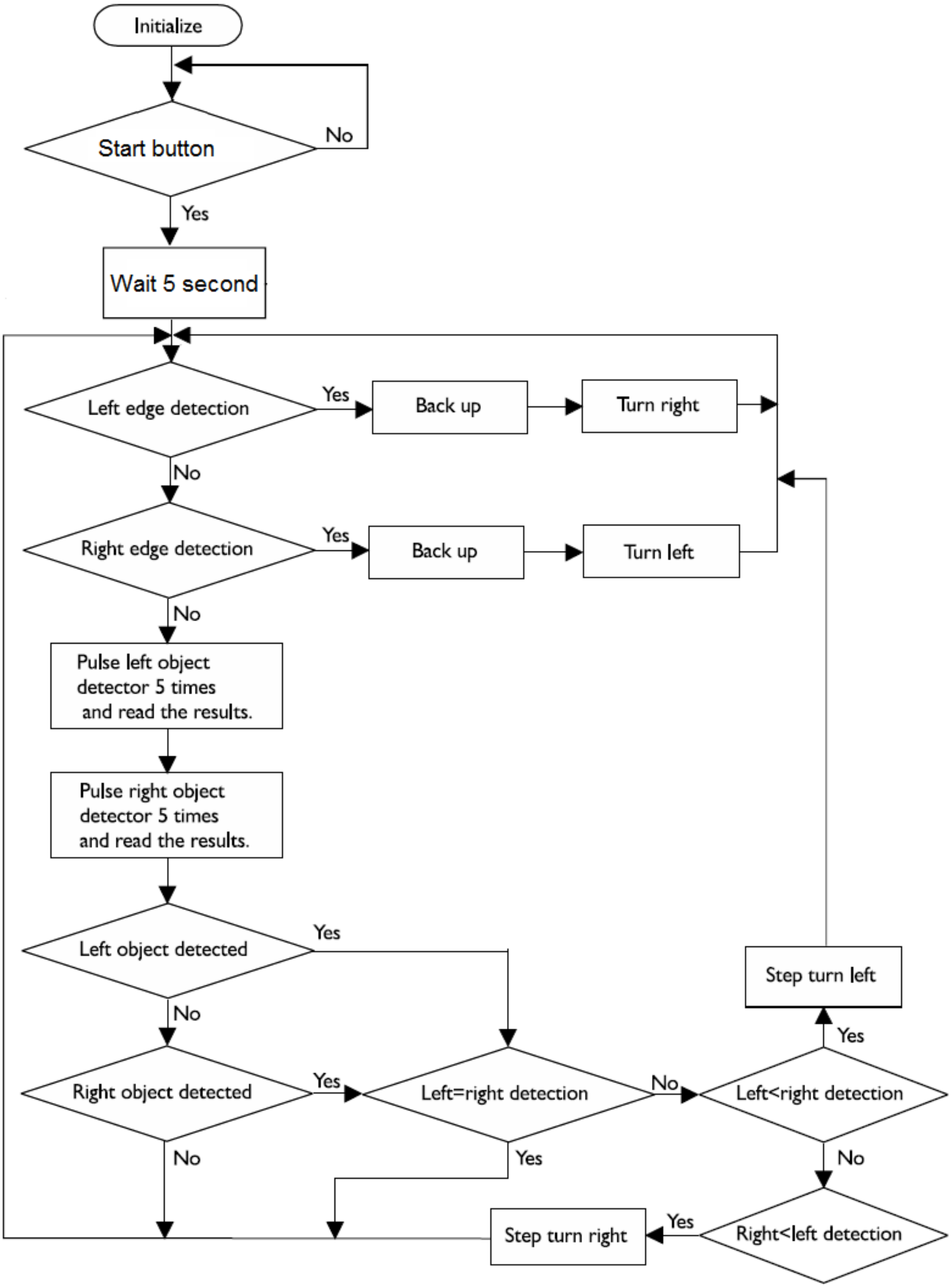

Fig. 9. Flowchart for Autonomous Mini-Sumo Robot.

InFiRo mini-sumo robot competition

University of Karabuk, Faculty of Technology (P4),
Transferring, Adopting and Developing Software (WP5)

In order to begin to make a robot, mini sumo robot is one of the best applications to learn the idea of a robot. A basic robot has sensors, microcontroller and actuators. Mini sumo robot has contrast sensors, approximate sensors, microcontroller and dc motors. That is the idea of making basic robot application for students. In order to make a mini sumo robot competition, the paper shows what to do. A mini sumo robot competition has been done in Croatia, Rabac for European Union, Leonardo da Vinci Project named Infiro (Integrated Physics Approach to Robotics Designed Laboratory).

1. Introduction of Mini Sumo Robot

Mini sumo robot has international rules. Diameters of wide and length cannot exceed 10 cm and no restriction for height. There is no restriction with height. Weight of a mini sumo robot needs to be less than 500 grams (Fig. 1.). Mini sumo robots shouldn't have equipment which can harm opponents' sensors, circuit or mechanical parts. They need to be designed to push the other one (Fig. 2.). Mini sumo robots need to work autonomously. They are programmed to find another mini sumo robot. Two robots attempt to push each other out of a circle (in a similar fashion to the sport of sumo). They work on black surface ring called "dohyo". If one of them falls down from the dohyo, it loses one round. If one mini sumo robot wins two rounds, it wins the match.

2. Dohyo

There is a 77 diameter ring called dohyo which has hard rubber black surface and edge of it has white surface for 2,5 cm wide (see Fig. 3. and Table 1). There are two brown lines to help opponents and referees where to locate mini sumo robots. The lines are 10 cm long and there is 10 cm difference between them and fully parallel. Only two mini sumo robot can be on dohyo for fighting each other. The object is to stay in the ring while pushing the opposing robot out of the ring. Referees are needed to make right choice in and during a match.

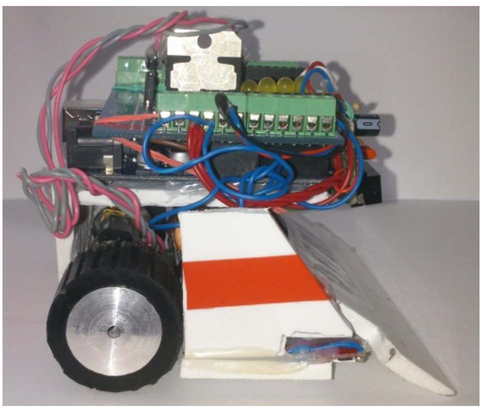


Fig. 1. Mini-Sumo Robot.

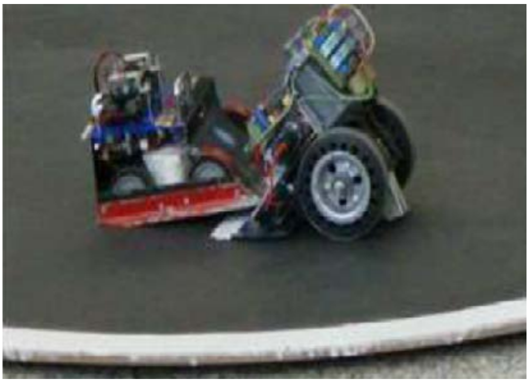

Fig. 2. Mini-Sumo Robot Matches.

Table 1. Specification of Mini Sumo Robot'sDohyo

Diameter	77 cm / 30.3 in.
Height	2.5 cm / 1 in.
Surface	Hard Rubber
Ring	Black
Start line	Brown (10 cm x 1 cm / 3.9 in. x 0.39 in.)
Border	White (2.5 cm / 1 in.)

3. Referee

Referees are needed to teach how the mini sumo robots work. In a competition, mini sumo robots have to be measured, checked and weighted before every match whether or not they are legal by desk referees. Before a match the referee has to help competitors to locate mini sumo robots. The referee has to warn competitors who start mini sumo robot about his or her own mark like "start", "3, 2, 1, go" so on. After referee's mark competitors need to start their robots. After 5 seconds, robots should move. In order to catch earlier moving, referees have to use chronometer. If any earlier moving occurs, referees have to warn the earlier moving one. If the error is happened twice, the mini sumo robot loses the round.

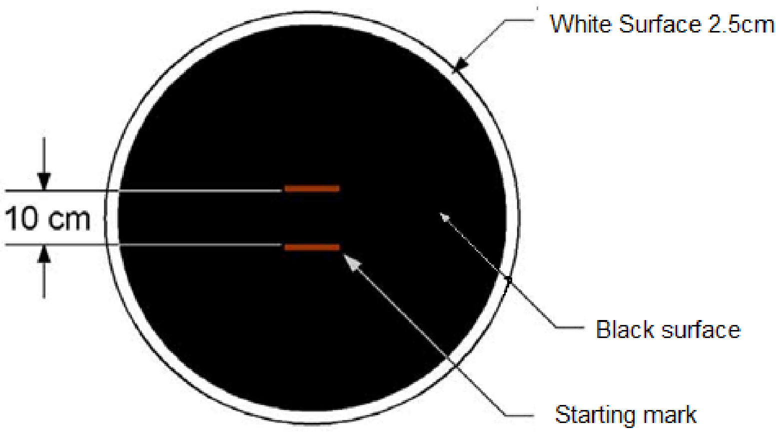

Fig. 3. Dohyo

4. Summer School Competition

On July 2013, a sumo robot competition has been made in Croatia, Rabac for European Union, Leonardo da Vinci project named Infiro (Integrated Physics Approach to Robotics Designed Laboratory). 3 groups made their mini sumo robots. Each group has 2 students aged from 12 to 15. Group members are from Turkey, Croatia and Slovenia. They built their mini sumo robots in 4 days. They were in competition on 5th day. They enjoyed very well during building and competition period. They learnt a lot of knowledge about electronics, sensors, algorithm and mini sumo robot (Fig. 4.).

5. Conclusion

Mini sumo robot has main target of a real robot. Making mini sumo robot is enjoyable, competitive and cheap. Also making a competition is cheap and enjoyable. This paper would help people to make a competition. In paper, mini sumo robot rules, specifications of dohyo and rules referees execute have been revealed.

Fig. 4. Summer School Mini Sumo Robot Competition

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Can we play robotics with wooden blocks?

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Many commercial structural composites give us opportunity to build complex structures but also with an alternative in the application of structural composites are some options to make something interesting too. In developing and manufacturing of the structural composite, a lot of attention was dedicated mainly to the usability and attainability of the constructs and materials. Constructs are made of pine and balsa wood, and of foamy PVC material, which is nowadays obtainable in almost every store that sells technical goods or goods for model building. All constructs and integral parts are compatible of the composite with the eProDas-Rob1 interface and the associated electronic components (servo motor, light sensor, etc.). With these alternative structural composites can be built a barrier or a mobile robot.

1. Introduction

In most cases, the structural composite does not include the full range of activities that would be in the context of an elective subject robotics in technical education [1] to be deduced. They are confined to this particular structural composite. For most schools commercial collections are also expensive, preventing them from successfully carrying out the elective subject robotics in technical education. That is why we created new and cheaper design puzzle that will suffice for successful completion of the elective subject in robotics engineering. Thus, this puzzle together with the interface eProDas - Rob1 gives the possibility of processing building blocks of the types of treatment that are pupils taught in 6th, 7th and 8th class in the Slovene primary schools in technical education. The collections allow students to independently create from old projects as well as create new projects. This can be done through the use of a free, computer programs (Google Sketch Up , CiciCAd , Bascom ...). With those programs and knowledge processing materials (wood, plastic ...) they can make a plan, blueprint and a variety of widgets. Commercial collections do not involve that. New structural composite covers the basic building blocks, sensors, motors, controller and tools. With them they can very easily build, for example, a model of a barrier, which can, by pressing different keys, be descended or lift, or a model of a mobile robot, which will follow a dark line.

2. Commercial structural composite

Teacher or mentor needs to derive an elective subject in school or group in summer schools of robotics and electronics. In addition to knowledge of robotics as material with which it is possible to assemble the model you want to be able to show students the basics of robotics. In schools dominate commercial structural composites (Fig. 1., 2.) brands Fischertechnik and Lego [5], which include measuring-control modules, sensors, motors, lights and building blocks to produce the individual structures. These components are designed and applied only to the composition of the particular structural composite because the composite themselves and their building blocks are not compatible with each other. The controllers that came with the above-mentioned commercial puzzle are not compatible, and they also cannot be used, with any other, home structural composite.

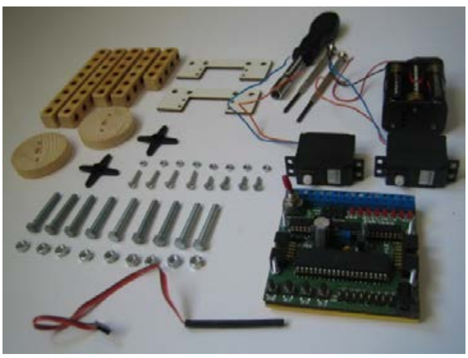
Fig. 1. : Puzzle Fischertechnik Profi E-Tec [2]   Fig. 2: Puzzle Lego Mindstorms NXT [3]

3. Structural composite

For using structural composite we need to have individual constructs and integral parts, tools, PC and controller with software. In this chapter the controller eProDas-Rob1 with its equipment, software program Bascom, unprocessed and processed servo motor, electronic component (photoresistors) as well as new building blocks is used for the construction of the puzzle.
The total development of the new alternative structural composite was adjusted that all individual constructs and integral parts are compatible with the above-mentioned equipment (Fig. 3., 4.).
In structural composite are next individual constructs and integral parts:

- 1 x pine wooden blocks stick-4
- 2 x pine wooden blocks stick-6
- 2 x pine wooden blocks stick-8
- 2 x pine wooden wheel (Ø 50 mm)
- 2 x PVC integral parts sercon-C
- 1 x PVC integral parts sercon-I
- 9 x screw (M5)
- 8 x screw (M3)

Needed tools and equipment: screwdriver with diferent socket wrenches
- 1 x controller
- 1 x unprocessed and 2 x processed servo motor, ≥ 1 x electronic component (photoresistors)



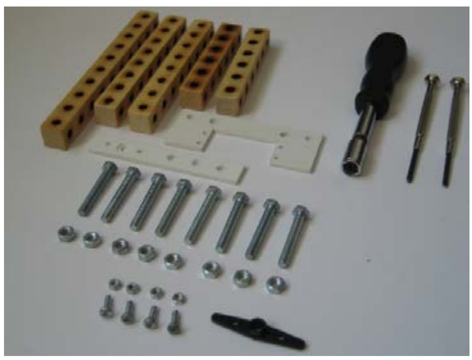


Fig. 3. Construction material for the mobile robot & Fig. 4. and for the barrier

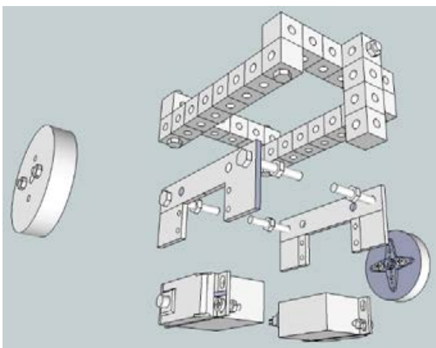
Thus, constructs were made of pine and balsa wood, and of foamy PVC material, which is nowadays obtainable in almost every store that sells technical goods or goods for model building [4].

4. Construction tasks

While teaching students in school and participants in summer school the robotics we first show how the barrier and a mobile robot work. That is demonstrated with previously built models. All needed equipment is already placed in front of participants in order to get an orientation what is required to build barrier or a mobile robot. The procedure is shown on a presentation with Google SketchUp (Fig. 5.). All constructs and integral parts are ergonomically designed, user friendly and easy to handle with. Wooden blocks and integral parts are attached with a screw; so also working tool (screwdriver) is required. (Fig. 6.)

5. Robotics summer camps

Participants of summer schools of robotics and electronics 2012 and 2013 have used this structural composite and it was good example of an alternative in the application of structural composites. So we have had an excellent opportunity to compose unique structural compositions. On both camps participants had an opportunity for brainstorming, which have led to amazing creativity. Some workshop participants have also processed and changed some constructs and integral parts. On Fig. 7. and Fig. 8. are some projects, which have been built by participants of summer schools.



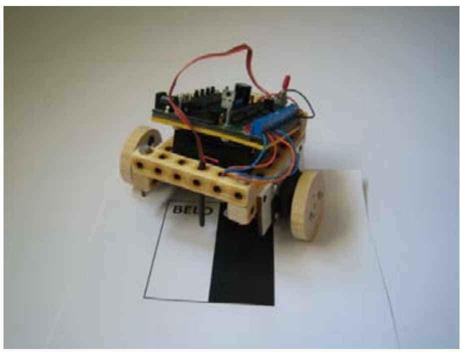


Fig. 5. Mobile robot in Google Sketch Up
Fig. 6. Mobile robot with sensor

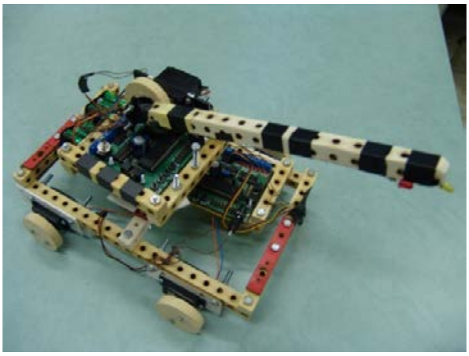


Fig. 7. Mobile tank with cupola
Fig. 8. Construction built in summer school of robotics 2013

6. Results and conclusions

On the market one can buy many different commercial structural composites. The majority of those give us opportunity to build complex structures. On both summer schools participants were using new structural composites and their finished projects are a good view of its usability. New wooden structural composite have proven that also with alternative materials can do robotics as well. At the end we can easily say that robotics can be done with wooden blocks.

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Experimental setups (prepared by collaborators from Labin, Croatia, Zagreb, Croatia and Bucharest, Romania)

1. Absorption of light

DESCRIPTION OF THE EXPERIMENT

An incandescent bulb lights two surfaces of different colors, one white, the other black. Then we use the same material in order to find a link between the radiation induced by the bulb and the distance.

MATERIALS

- incandescent bulbs from 60-100 W with a holder
- a holder base
- a thermometer with a sensitivity of 0.1 K (e.g., electronic temperature sensor LM35)
- a voltage source and a voltmeter
- a piece of white cardboard
- a piece of black cardboard
- a measure tape

DESCRIPTION OF THE PROCEDURE

It is a fact that darker objects receive heat better than brighter ones. In order to perform a quantitative comparison it is necessary to use two variations of the same object of different color and illuminate them under the same conditions. Some pieces of black and a few cm of a white cardboard cut from drawing sheets will be appropriate. Comparisons will be made using a very sensitive thermometer, which must be in contact with the pieces of cardboard. A bright light bulb is required as a radiation source; halogen bulbs are suitable considering that they mostly have short threads.

PREPARATIONS

Follow the instructions shown in Fig. 1. At the beginning distance r equals 20 to 30 cm.

EXECUTION OF EXPERIMENTS

Part I:
The first part of the experiment aims to prove that darker surfaces absorb radiation easier than brighter surfaces. With the bulb turned off, a piece of a white cardboard is laid on the sensor and you have to wait for the system to get a balanced temperature T_0. The temperature is measured in kelvins (note: to calculate the value in degrees Celsius just numerically subtract 273.15). Then turn the lamp on and wait for the sensor to reach a new balanced temperature T_b. Record the resulting temperature and replace the white cardboard with the black one. Wait until the sensor reaches a new balanced temperature T_n and write it down. Comparing these two temperatures, it can be seen that the following applies: Tn > Tb . Thus, we can conclude that the black cardboard absorbs energy radiation better than the white cardboard.

Part II:
Turn the bulb off and wait for the temperature of the system to return to the initial temperature T_0. In the meantime, move the bulb away from the sensor (r ≈ 30-40 cm). Gradually increase the distance r and record the new balanced temperature T. Do the experiment with the white cardboard, then with the black one. Write the data down in Table 1 and Table 2.

DATA ANALYSIS

Let us analyze the data of the second part. When we move the lamp closer to the sensor, the temperature increases.

• square differences of inverse proportionality law: the radiant energy E of a surface (the radiant energy that hits a unit of an area each second) decreases inversely with the square of the distance r from the source:

$$E \propto 1/r^2$$

It is measured in W/m^2. This law is a consequence of the geometric fact that the same energy hits, every second, the inside of the spherical surface whose surface is proportional to the square of the radius r ($A = 4\pi r^2$). The Stefan - Boltzmann law: the intensity of radiation of a body at a temperature T (the radiant energy that hits a unit of an area each second) is proportional to the fourth potency of the absolute temperature :

$$I = a \cdot T^4$$

where a is a constant that depends on the type of the material of a body (eg a changes depending on the color oft he card (white or black)). Also I is measured in W/m2. To calculate the radiated energy of a body with the surface of A, it is necessary to multiply the radiation intensity I with A.

• The Kirchhoff law : it essentially confirms the fact that a surface that absorbs radiation well will also radiate well , and vice versa . In other words the constant *a* of the Stefan- Boltzmann law is equal for both absorption and radiation.

Using these laws, let's analyze what happened during these experiments. When the temperature of the sensor and the cardboard are stable, i.e., when the system is in equilibrium, the amount of radiation (the amount of the energy emitted per second) is equal to the amount of the absorption. Let's assume that the bulb is switched off. The amount of radiation of the system (sensor + card) is $A \cdot a \cdot T_0^4$. The system then is in balance with the environment. When the bulb is switched on, the equilibrium temperature of the system sensor + the card is T, which is higher than T_0 . Therefore the system radiates the energy of $A \cdot a \cdot T^4$ every second, which is higher than the former. But now the amount of the radiation energy absorbed every second is higher because the system receives energy from the lamp. Since the temperature is stable, the system is in a new state of equilibrium in which the radiated energy is equal to the energy that is absorbed:

$$A \cdot a \cdot T^4 = A \cdot a \cdot T_0^4 + A \cdot \frac{b}{r^2}$$

The three expressions appearing in this equality have the following meanings:

$A \cdot a \cdot T^4$: The energy emitted by the system every second (sensor + card) ;

$A \cdot a \cdot T_0^4$: The energy absorbed by the system every second, derived from the surroundings;

$A \cdot \frac{b}{r^2}$: Energy absorbed by the system every second, derived from the bulb (b depends on the strength of the emitting light bulbs and it is constant if the radiation intensity lamp is fixed , as in our case).

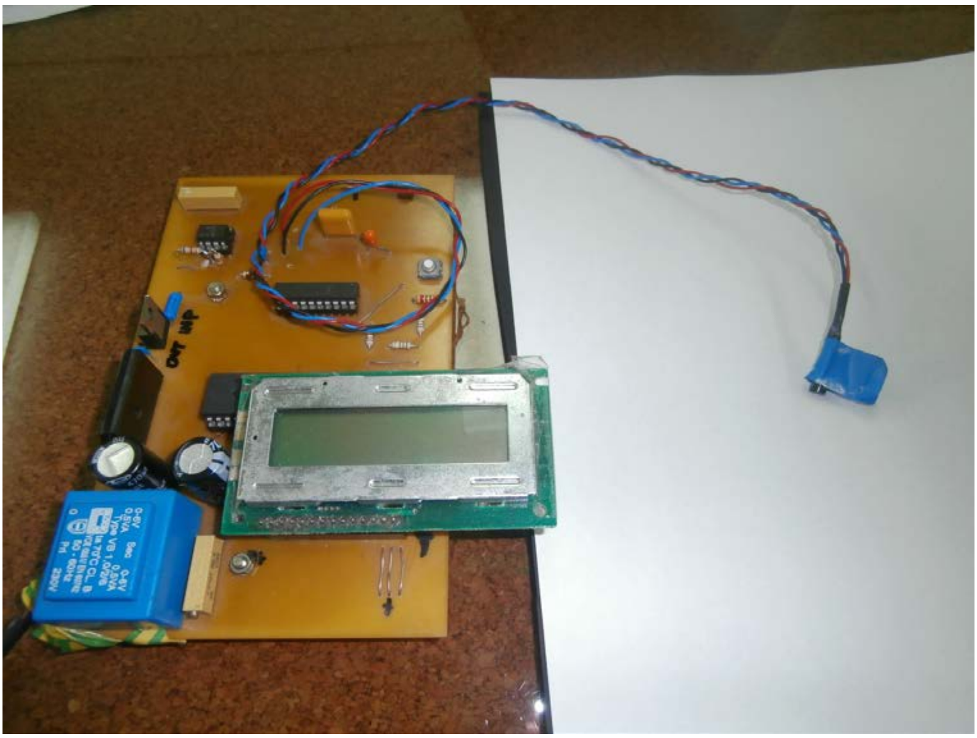
This equality can be written as:

$$(T^4 - T_0^4) \cdot r^2 = \frac{b}{a}$$

Where $\frac{b}{a}$ is a constant .In the tables 1 and 2 pillars are used for the calculation of this term. If we took the measures correctly, first from the black cardboard, then from the white one, we expect the contents of the last column to be constant (within acceptable experimental errors). This result proves that the radiation of the system sensor + card received from the bulb (ie energy absorbed by the surface of each second) obeys the Stefan- Boltzmann law . Due to the errors in measurement, the amount of $c = (T^4 + T_0^4) \cdot r^2$ is not exactly constant and error originates from $\Delta c : 2r \cdot (T^4 - T_0^4)\Delta r + 4(T^3 \Delta T + T_0^3 \Delta T_0) \cdot r^2$.

Hereby we did not prove the validity of the equation, but it is important to note that due to the dependence on the temperature, the error can be great.

Our way of getting to the formula $(T^4 + T_0^4) \cdot r^2$ = the constant was relatively simple.



APSORPTION OF LIGHT

WHITE CARDBOARD

R (m)	R^2 (m^2)	T_0 (°C)	T (°C)	$(T^4 - T_0^4) * R^2$
0,17	0,0289	27,31	31,98	1,42E+04
0,20	0,0400	27,62	31,36	1,54E+04
0,28	0,0784	26,07	28,56	1,59E+04
0,34	0,1156	26,69	27,93	1,17E+04
0,42	0,1764	26,38	27,31	1,27E+04

BLACK CARDBOARD

R (m)	R^2 (m^2)	T_0 (°C)	T (°C)	$(T^4 - T_0^4) * R^2$
0,18	0,032	27,62	0,00	-1,89E+04
0,20	0,040	28,56	36,02	4,07E+04
0,24	0,058	26,38	0,00	-2,79E+04
0,34	0,116	27,62	30,11	2,77E+04
0,42	0,176	26,38	28,87	3,71E+04
0,52	0,270	27,00	28,25	2,85E+04

R (m) →	0,17	0,20	0,28	0,34	0,42	0,18	0,20	0,24	0,34	0,42	0,52
t (s)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)	T (°C)
30	27,31	27,62	26,07	26,69	26,38	27,62	28,56	26,38	27,62	26,38	27,00
60	28,25	28,25	26,38	27,00	26,69	29,49	30,42	27,62	28,25	27,00	27,31
90	28,87	28,87	26,69	27,00	27,00	30,73	31,36	28,56	28,56	27,31	27,31

2. Determining the Planck constant by a LED

EXPERIMENT DESCRIPTION

The aim of the experiment is to determine the value of Planck's constant h using the characteristics of a light emitting diode (LED) , with which we will develop the characteristic curve.

ACCESSORIES

- LEDs in various colors
- a variable source of low dc voltage
- a voltmeter and an ammeter or two multimeters
- Connecting wires

DESCRIPTION OF THE PROCEDURE

When the LED lights up, photons with a wavelength belonging to visible light are emitted. This occurs when the LED is connected in the permeable direction. The electrons and holes in the interior get recombined which releases the energy corresponding to difference between the valence and the conduction band. The energy carried by each photon is:

$$E = h\frac{c}{\lambda},$$

where h is the Planck's constant, c is the speed of light and λ the wavelength of the emitted radiation. We can get the value of h by measuring E and λ; λ can be observed, at least approximately, by the color of the light emitted, the energy E is produced by the effect of the Eu electric field that is applied to the circuit. The value of U, the difference in the potential of the LED field, is measurable with a voltmeter connected in parallel: the data we are interested in corresponds to the moment at which the LED begins to conduct, that value will be obtained through the characteristic curve. This process will have a certain degree of arbitrariness, which makes the determination of the constant h somewhat uncertain; also, the value of the difference of energy, which depends on the conductivity, under the influence of temperature of the diodes, except for these inaccuracies, it is important to determine the order of the size of the constant h.

PREPARATIONS

We will connect the circuit shown in Fig. 1., similar to the one prepared for the experiment, which refers to the voltage - current curve of one diode. We have to be careful when connecting the LED so that it must be in the permeable direction.

EXECUTION OF THE EXPERIMENT

The characteristic curve of the LED is obtained using the same procedure used for recording the semiconducting diode. It is advised to perform the procedure with more LEDs, so the results can be compared. Because of that it is necessary to make more copies of the diode table sheet. If we place the LED in the circuit and slowly, but gradually, increase the positive voltage, we can

determine the precise moment the LED begins to emit light (except for possible cases of infrared LED).
After the initial control, measurement begins with the collection of data on the voltage and current for the time when the LED does not emit light, and the time when it does, especially focusing on the moment of ignition. Stop measuring when the emitted light becomes intense. Record the details on table 1, by also entering the possible error. Finally, replace the LED with a LED of a different color and repeat the process.

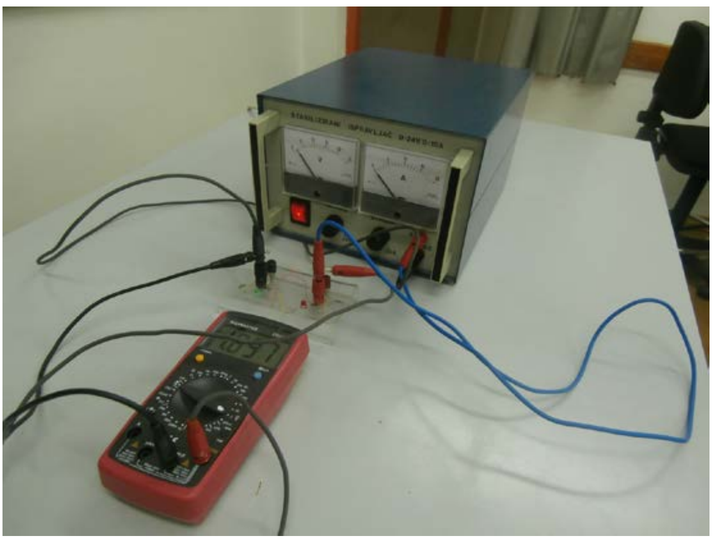
RESULT ANALYSIS

The curve generally represents an approximately horizontal section close to the origin, and then begins to rise sharply to ultimately end straight. We are interested in finding the coordinates of the graph where it begins to grow, because they correspond to the moment at which the work of the eU electric field is sufficient to broadcast a photon with the energy hv; find that area and note the voltage value in the table, with some possible error, whether it coincides with what was previously identified as the value where the LED started emitting light? The process requires a wavelength of emitted light; if it is not possible to calculate it or find out the nominal value indicated by the manufacturer, then we use the data from a table that contains wavelengths that are indicative of the majority of manufacturers of LEDs .
Knowing the value of the electric charge and the speed of light, we can easily calculate the value h :

$$h = \frac{eU\lambda}{c}$$

POSSIBLE ERROR OF THE RESULTS

How much does the value of h we obtained differ from the value contained in the manuals? Does repeating the measurement with different colored LEDs give different values of h? Which of the LEDs requires the lowest minimum voltage for conductivity? And which requires the highest?



n	U /V	I /A
1		
2		
3		
4		
5		
Average value		

n	U /V	I /A
1		
2		
3		
4		
5		
Average value		

e =	1,60E-19	C
c =	3,00E+08	ms^{-1}
h =		
p =		

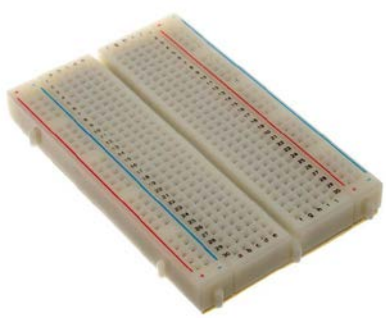
	BLUE		GREEN		YELLOW		ORANGE		RED		INFRARED	
λ =	4,70E-07	m	5,65E-07	m	5,90E-07	m	6,30E-07	m	6,60E-07	m	9,40E-07	m
V =		V		V		V		V		V		V
h =		J*s		J*s		J*s		J*s		J*s		J*s

n	*V* (V)	*i* (A)	*V* (V)	*i* (A)	*V* (V)	*i* (A)	*V* (V)	*i* (A)	*V* (V)	*i* (A)	*V* (V)	*i* (A)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

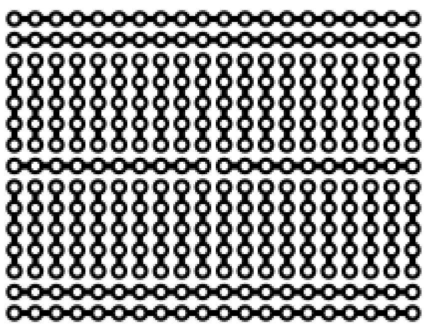
Basic electrical circuits on the protoboard

Darko Androić, Željko Brenčić, Nedeljko Mandić

School exercises in electrical circuits are generally performed using elements on a specific stand with the corresponding connectors for connecting using wires. This allows for simpler and safer connecting of the elements. To perform independent lab exercises, you require a lot of elements (resistors, light bulbs, capacitors, inductor coils, diodes, transistors etc.). They are very expensive and, because of that, schools generally have only one set for frontal exercises.
You can also perform exercises on computers, but that way students cannot get the real perception of the real elements nor learn to connect electrical circuits and measure using instruments.
Instead of one of these ways, you can perform electrical circuit exercises using a protoboard.
A protoboard is a board used to connect different circuits. It is generally used in electronics to check circuits before making printed circuit boards (PCB).
The protoboard consists of a series of holes in which you place real circuit elements without using banana connectors. The red line marks the positive pole, and the blue one the negative pole of the power source. Every hole in the same row are on the same electrical potential.
The pros of the protoboard are simple usage and a low price, allowing a larger number of students to simultaneously perform independent excercises. The visual design of the circuits on the protoboard is closer to real PCB circuits. This is specifically designed for students of vocational schools and high school students planning on studying electrical science.
A minor difficulty is that during the first few uses the protoboard requires the student to be skilled in placing the elements and wires in the holes. Using the protoboard, the students quickly acquire that skill.
On the workshop the participants had ten sets to perform their excercises at their disposal. Each set came with a protoboard with a regulated voltage source (3 V, 5 V, 6 V, 9 V, 12 V and 15 V), a universal measuring instrument as well as passive (resistors) and active (diodes and transistors) elements.
Using the protoboard and elements, the students performed the following excercises: Ohm's law, Series, parallel and combined resistor connections, recording the I-V graph of a semiconductor diode and transistor amplification.



Protoboard



Protoboard connections

3. Basic electronic circuits

INTRODUCTION

The same exercises are performed on an electronic module and by using Electronics Workbench [1)] (The electronics lab in a computer).
The aim of this exercise, besides being educational, is:

To examine the functionality and ease of use electronic module. To compare the results between the simulation and reality.

Electronics Workbench is an electronic lab in a computer. You can easily build an analog or digital circuit schematic, attach simulated test instrument, and turn on the power to see how it works.

RECTIFIER CIRCUITS

Half-Wave Rectifier Circuit

General

In circuits in which semiconductor diodes are inserted, a current can only flow (on-state range) when the applied current has a certain polarity. If the polarity of the voltage is reversed, the off-state range of the diode becomes effective, preventing current from flowing. In circuits such as these are fed with AC voltage, current only flows during the half-wave at which diode is in the on-state. The other half wave is suppressed. The current in the circuit only flows in one direction.

Experiments

Examine the rectifying effect of a semiconductor diode in a half-wave rectifier and examine its properties (with and without smoothing capacitor) with the multimeter and the oscilloscope.

Procedure

Set up the circuit according to Fig.1.1. with the support of Electronics Workbench and measure the DC output voltage Ud with the multimeter and calculate ratio Ud/24VAC.
Then record 24VAC and the DC output voltage with the oscilloscope and transfer their curve shape onto the diagram. Do the same with the smoothing capacitor.
Then do the same measurement on the electronic module and compare results

Bridge Rectifier Circuit (*Graetz bridge*)

General

The half-wave rectifier circuit only makes use of the one half-wave of the AC voltage. This has the disadvantage of a low DC voltage and a high ripple. This disadvantage is avoided with the bridge rectifier circuit: the opposite half-wave are reversed in polarity and added to the DC voltage.

Experiments

Measure the properties of a bridge rectifier with the oscilloscope and the multimeter.

Procedure

Make the same measurements as with the Half-Wave Rectifier Circuit

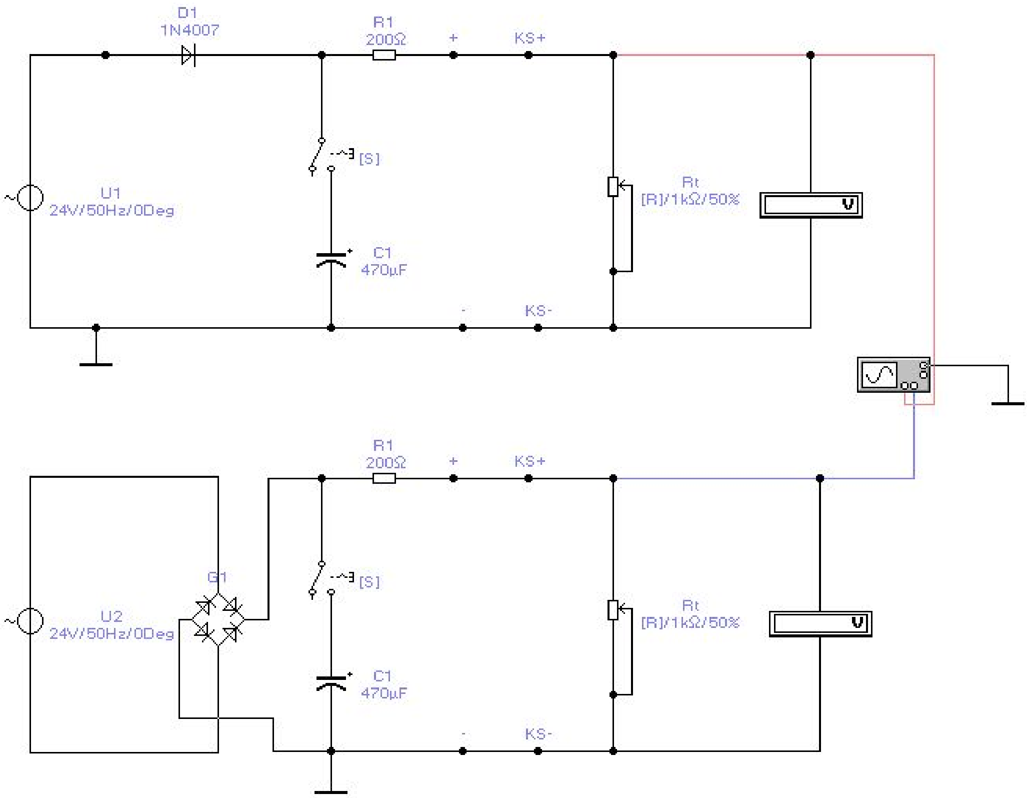


Fig.1.1. Rectifier Circuits - simulation using Electronics Workbench

OPERATIONAL AMPLIFIERS

Introduction

Operational amplifiers are ideal DC voltage amplifiers with high-resistance differential inputs and a very high gain factor.

Operational amplifiers are available as integrated standard components (e.g. μA741). The following experiments are designed to examine the basic properties of these components.

Operating Amplifier as Inverting Amplifier

Inverting amplifiers are circuit arrangements in which the input voltage is inverted at the output. With AC voltage there is a phase shift of 180^0 between the input and output voltages. An

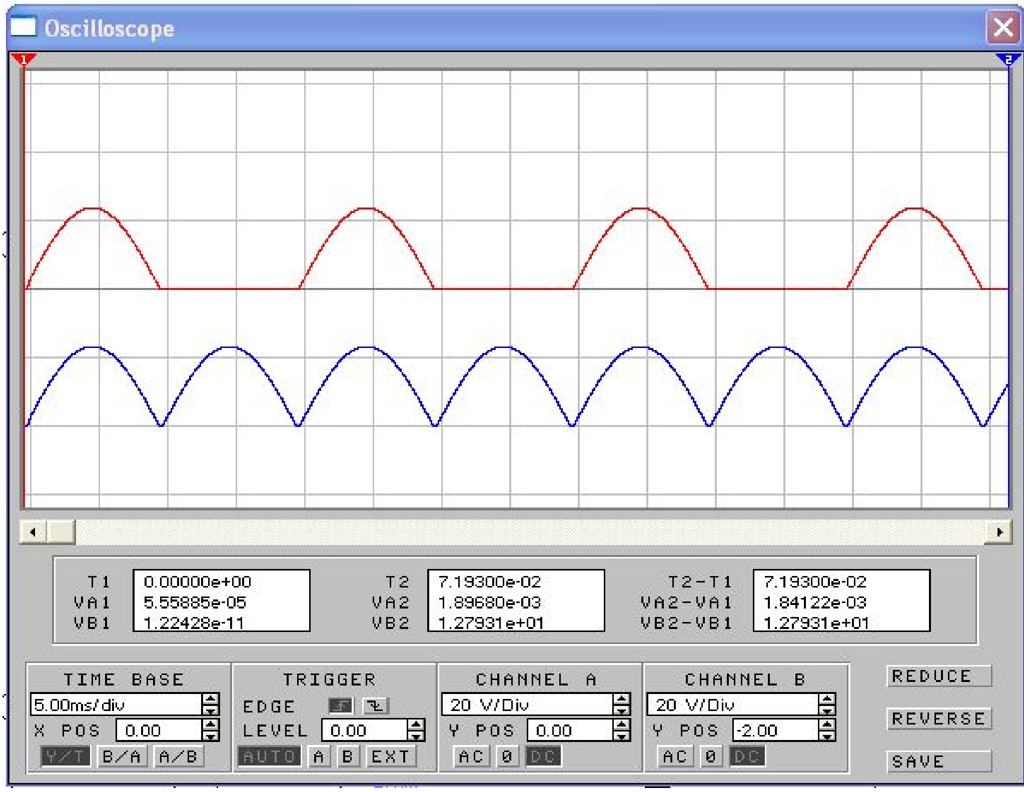


Fig.1.2. Record of the output voltages with the Electronics Workbench oscilloscope

inverting amplifier can be used to amplify or to reduce the input signal according to the size of resistors R2 and R1.

Gain factor : A = -R2/R1 => Uiz = -R27R1*Uul1

Experiments

Measure the properties of an inverting amplifier with the oscilloscope and the multimeter.

Procedure

Set up the circuit according to Fig.2.1. with the support of Electronics Workbench.
Then record output voltages with the oscilloscope and transfer their curve shape onto the diagram. Then do the same measurement on the electronic module and compare the results.

Operating Amplifier as Non-Inverting Amplifier

In non-inverting amplifiers, input and output voltage have the same polarity; the phase shift with AC voltage is 0^0.

Gain factor: A = 1 + R2/R1 => Uiz = (1+R2/R1)*Uul1

Experiments

Measure the properties of an inverting amplifier with the oscilloscope and the multimeter.

Procedure

Make the same measurements as with the Inverting Amplifier

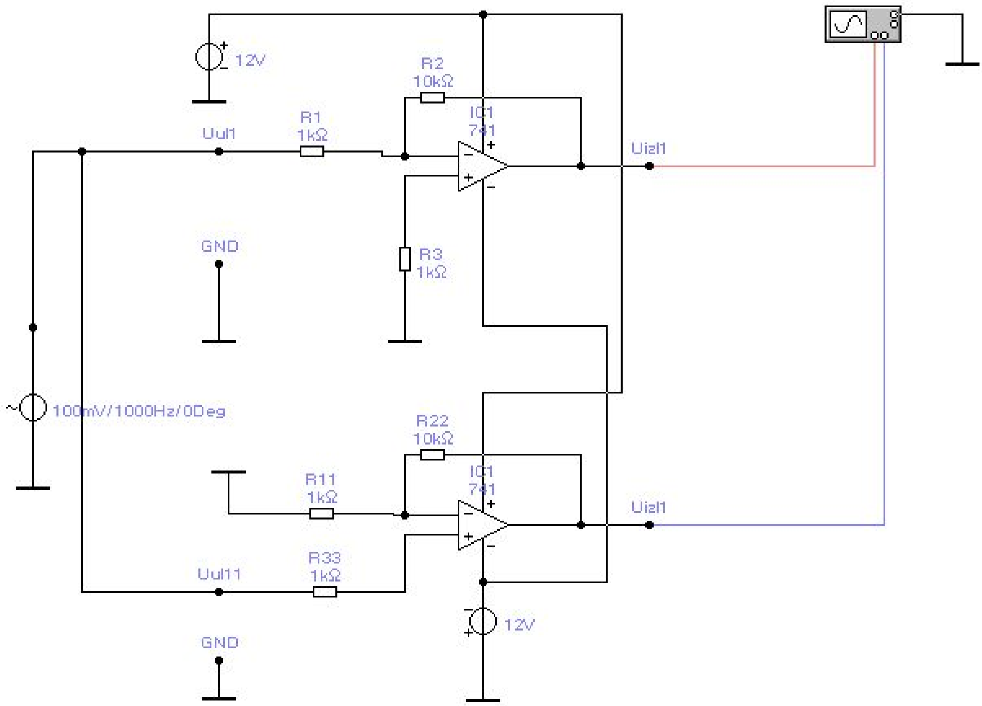


Fig.2. Operational amplifiers

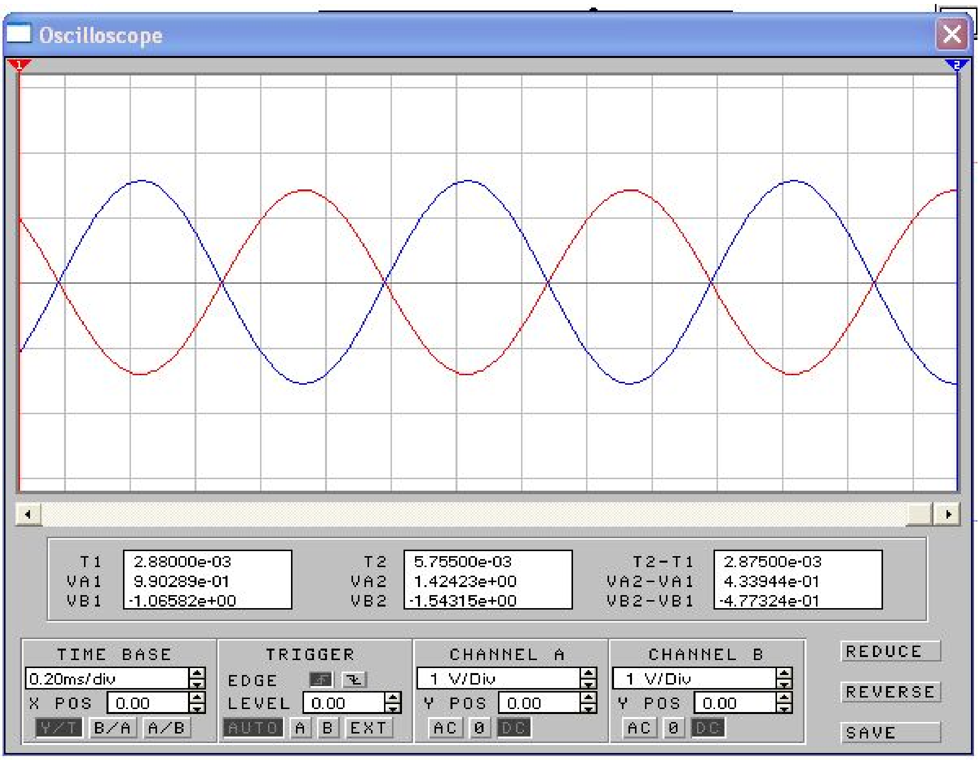


Fig.2.1. Operational Amplifiers - simulation using Electronics Workbench

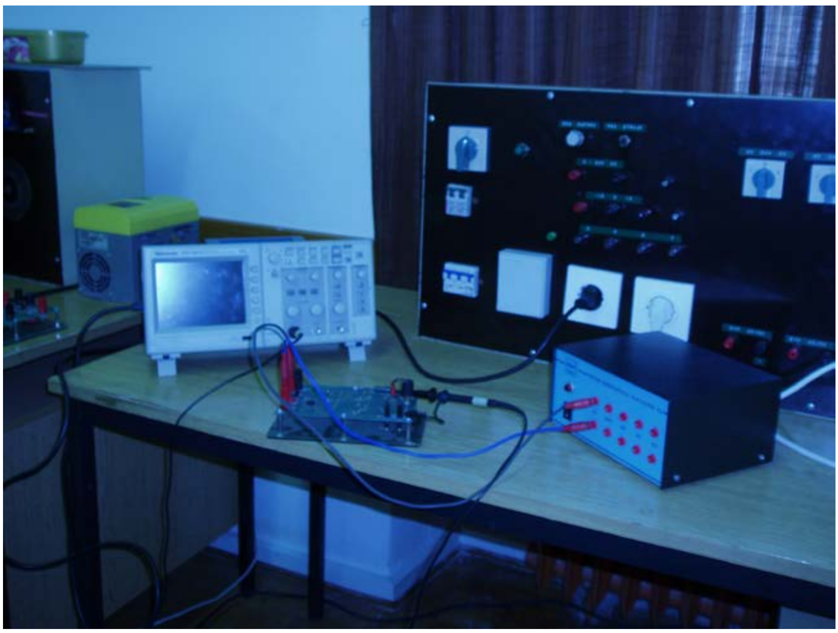


Fig.2.2. Record the output voltages with the Electronics Workbench oscilloscope

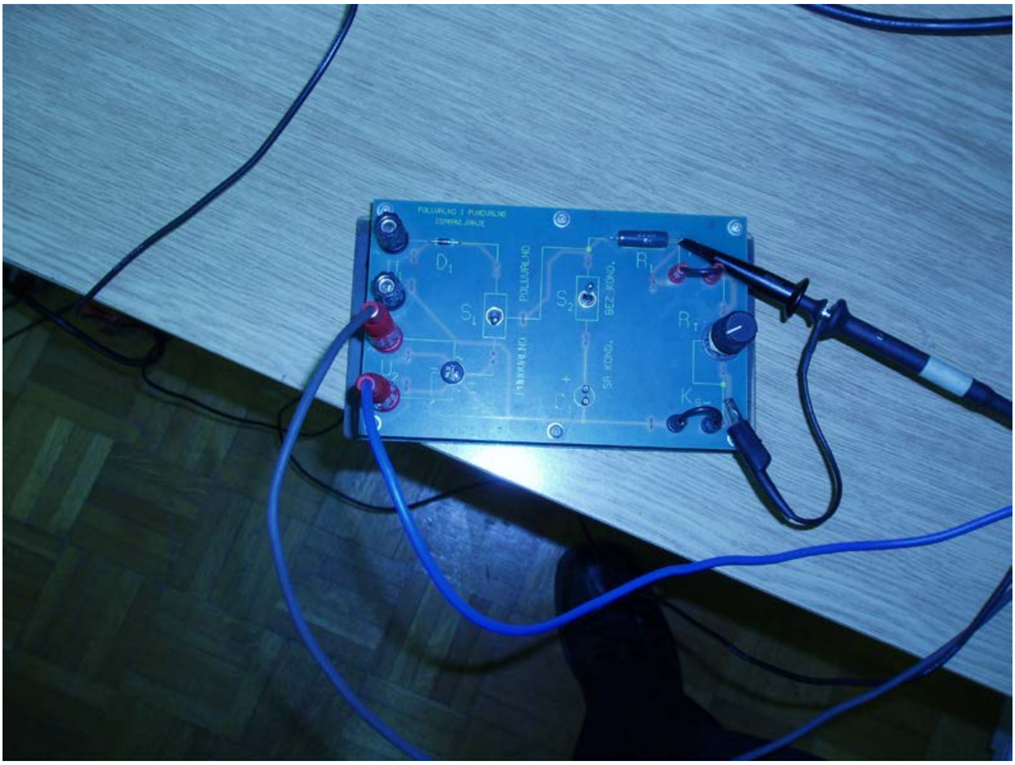


Fig.2.3. Record the output voltages on Electronic module

RCS - Robot Control Systems

Laboratory 1

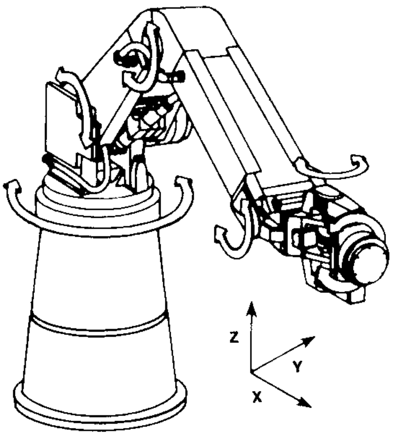
Robots - general structure - components - features

1. Aim

The purpose of this paper is to familiarize students with the concept of robot functioning, applications, components (joints, motors, sensors) thereof.

2. Proceedings

In carrying out the work it will be taken into account that there are different types of robots, different classes, different applications and different structures.



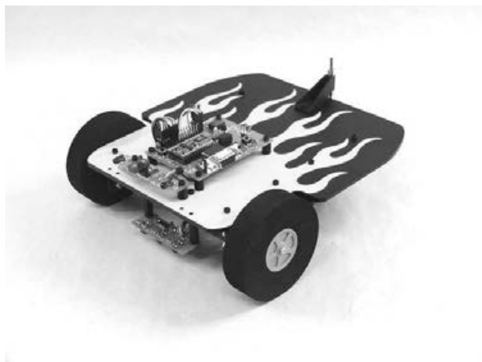


Fig. 1.
a) industrial robot
b) mobile robot (proximity sensors);
c) toy robot

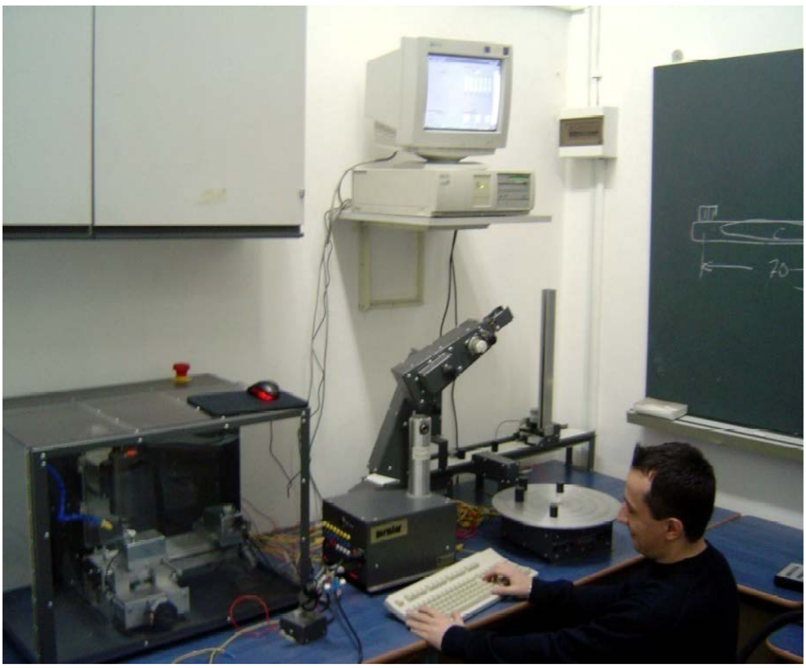
3. Conducting work

Students will choose one type of robot and seek the Internet using search engines, information about it; The documentation made will take into account the following elements:

- the use of the robot;
- type / class robot;
- structure;
- components (types, operation):
- sensors / transducers
- motors / actuators
- joints
- user.

4. Issues

Make a PowerPoint presentation and a written report describing the operation of a robot, components, fittings, sensors and applications of this robot.



Summer school of robotics exercises

Automated garage door

Design an automated system of opening/closing the garage door using Robopro-Fischertechnik.

The door is opened by the I1 entrance key (remote control). At the upper side, the door has got an I2 on switch, which shows that the door has been opened, while at the lower side, there is an I3 on switch showing that the door has been closed.

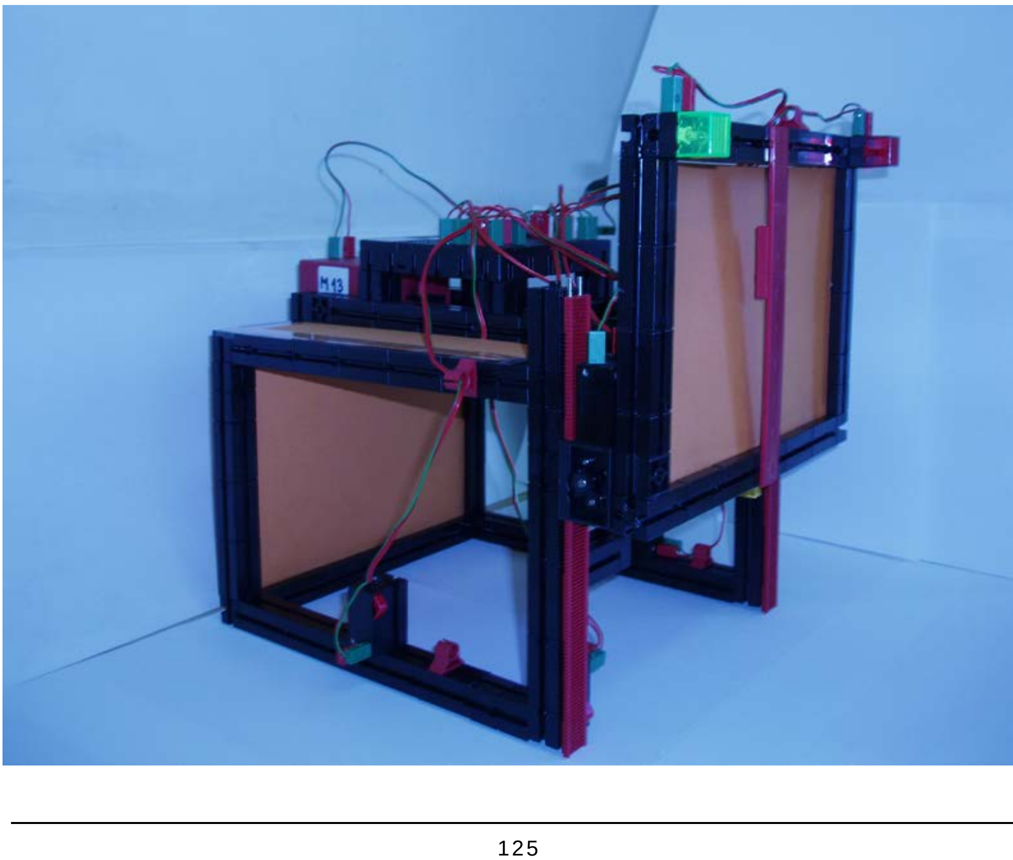
When the door is completely open, it is necessary to keep it open for 10 seconds and then the door will be automatically closed.

There is an optical sensor built in the door-case, which prevents the closing of the door in case there is someone underneath.

By interrupting the optical sensor beam, the door is automatically lifted to the upper end position and is kept in this position for 10 seconds after which it is automatically lowered!

In the garage there is an I5 key which makes it possible to keep the garage door open while cleaning it and by pressing the key again, the door is closed!

While opening/closing the door warning lights blink as well as messages appearing on the PC monitor.



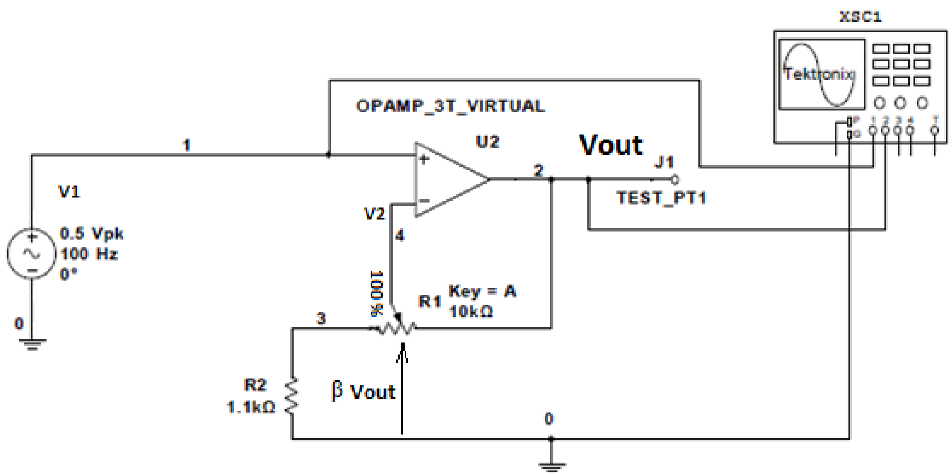
Operational amplifiers

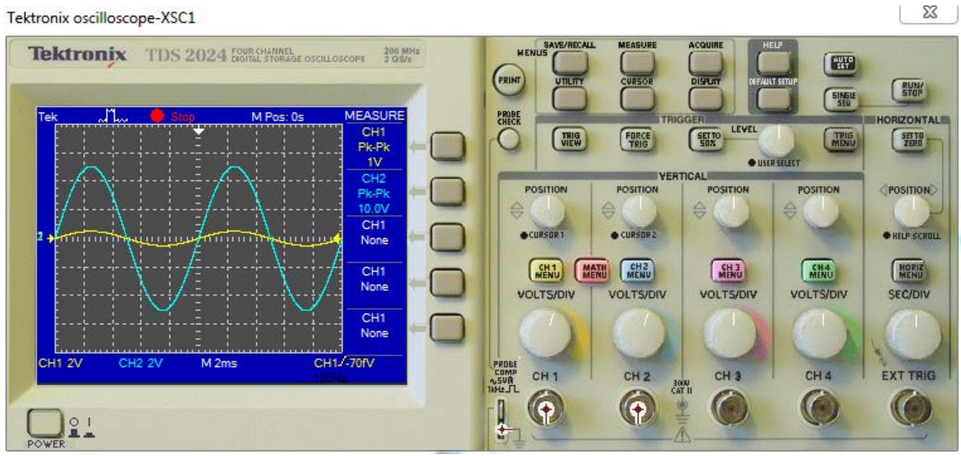
In this exercise we will review the operational amplifier **µA741,** make an expression for the amplification (closed-loop A), and record the input and output signals of the operational amplifier with an oscilloscope according to the following schematics!

Materials and instruments: NI myDAQ
Program Multisim 12.0
Experimental board
4 1/4W resistors (1k1;10k;100k;1MΩ)
Trimmer potentiometer 10 kΩ x 2
Operational amplifier µA741
Set of counductors

Draw the schematics of the non-invertive operational amplifier in NI MULTISIM 12.0!
Use the specific ANALOG/ANALOG_VIRTUAL/OPAM_3T_VIRTUAL operational amplifier and SOURCES/POWER_SOURCES/AC_POWER AC voltage source blocks.
Set the frequency to 100 Hz sinusoidal and the peak voltage to 0.5 V.
Connect the TETRONIX oscilloscope to the amp output (TEST_PT1) and make a SCREEN SHOT for trimmer positions 0% and 100% as seen in the figure.

Set the oscilloscope according to the figure from which is visible that the maximal amplification is **Closed-loop A=10**.
Excerpt an expression for the closed-loop amplification A depending on the feedback factor **β.** The operational amplifier has a gain bandwidth product of **GPB=1 MHz,** meaning that the product of the throughput frequency range and the **open loop gain Av=1Mhz**, that means that with a higher amplification comes a lower throughput range. Try to set the input frequency to 1kHz, and then to 100kHz!



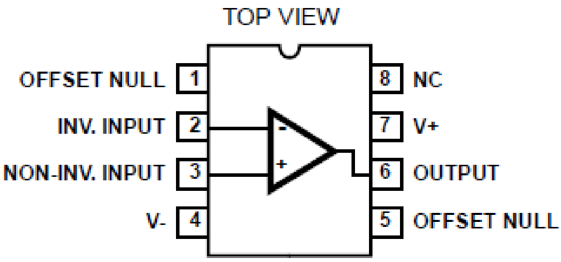


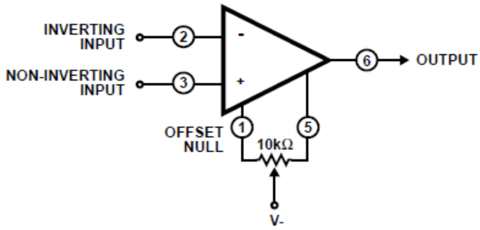
Since we set the **ideal operational amplifier** in NI Multisim, does the amplification change with the input frequency?

Write down your observations and excerpt an expression for the amplification A:

Connect the elements of the circuit according to the schematics on the experimental board! Keep in mind to connect the power supply for the OA (note that the +15V goes to pin 7, and the -15V to pin 4).

On the left figure there is the pin layout of the OA µA741. On the right is the offset calibration (when the input voltage is zero – short circuited input – then the output voltage must be zero).



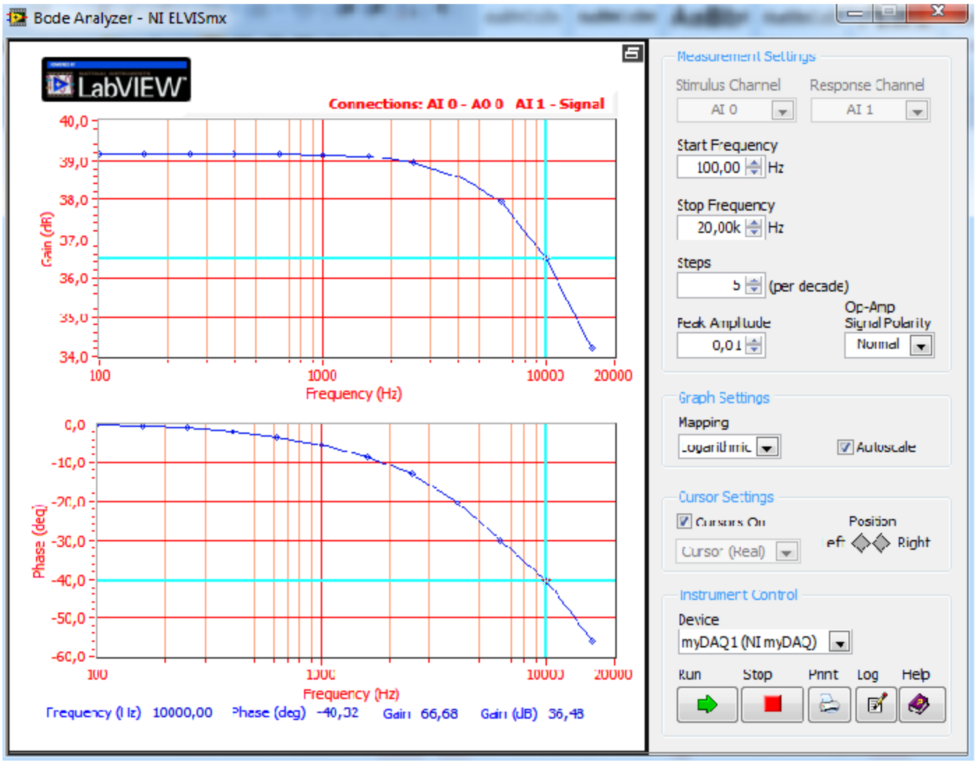


Using the function generator and NI ELVISmx instrument launcher (FGEN) you will get the input voltage V1 (100 Hz signal, 0.02 Vpp). On the non-invertive input of the OA (pin 3) connect AO 0. Connect AGDN to ground (GND).
Between pins 1 and 5 OA connect a 10kOhm trimmer potentiometer so that the slider is connected to -15V according to the schematics on the right. Set the R1=1MOhm resistor in the feedback loop. Open the oscilloscope (SCOPE) and set Scope CH0 AI0 to the input of the OA (pin 3), and observe the amplified signal on the output of the OA (pin 6) (Scope CH1 AI1). Change the FGEN frequency from 100Hz to 10kHz and record SCREEN SHOT for 100Hz, 1kHz and 10kHz!
Check the output amplification in decibels (A=20log Vout/Vin), and check the phase shift (how much is the output signal late compared to the input signal in degrees).

Express your observations :

Compare your results with the Bode's diagrams given in the figures for all listed frequency settings.

R1=1Mohm GBW=1 Mhz   A=1+1000k/1k1=910 fg=1000k/910=1,098 kHz
R1=100k GBW=1 Mhz   Av=1+100k/1k1=91,9 fg=1000k/91=10,88 kHz



Write down the measurements in the table!

Feedback resistance R1	**10 kΩ**			**100 kΩ**			**1 MΩ**		
	100 Hz	1 kHz	10 kHz	100 Hz	1 kHz	10 kHz	100 Hz	1 kHz	10 kHz
Gain A(x)									
Gain A(dB)									
Phase shift φ(º)									

Bode's diagrams given in the figures can be recorded by connecting AO 0 and AO 0+ on the non-invertive input of the OA (pin 3), AI1+ to the output of the OA (pin 6), and the AGND, AI0- and AI1- signals to the GND on the experimental board. Using the NI ELVISmx instrument launcher (BODE) you will get an amplitudal-phase-frequency diagram called Bode's diagram where the amplification, output phase shift and the upper peak frequency, which is for a feedback resistance of R1=100kOhm 10.88 kHz, are nicely visible in a logarithmical measure.

You can check this with a cursor.

Set the Bode analyzer like this:

Start frequency 100 Hz
Stop frequency 20 kHz
5 steps per decade
Peak 0,01V

Press the run icon and wait for the PC to draw Bode's diagrams for the non-invertive operational amplifier.
You can use the cursor to measure the upper peak frequency of the OA fu. That's the frequency where the amplification drops for 3 dB compared to DC signals, that is to 70.7%.
Check the signal phase, too. What's the output phase shift at the upper peak frequency?
Determine the slope of the amplitude characteristics from Bode's diagram in dB/sec!
Explain what does a decade mean in Bode's diagrams and why are the characteristics drawn in a log-log measure?

Express your observations :

Microphone preamplifiers

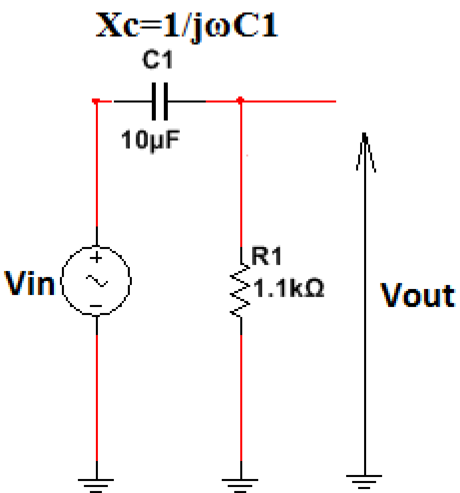
In the figure there are schematics of an non-invertive OA with a capacitive microphone connected to its input.

Materials and instruments: NI myDAQ
Program Multisim 12.0
Experimental board
4 1/4W resistors (1k1 x 2;10k x 2;100k)
Trimmer potentiometer 10 kΩ
Capacitor 10 μF
Operational amplifier μA741 x 2
Capacitive microphone
Speaker
Set of conductors

The microphone (red conductor) is powered through the R2=10kOhm resistor connected to +15V. The signal we need to amplify is taken through the C1=10μF capacitor and is lead to the non-invertive input of the OA (excerpt 3).
The capacitor is used to separate the directional voltage component, and lets through to the amp only the useful alternating signal that we need to amplify, the resistor is used to receive the input voltage on the non-invertive inout, and together they make a filter of low permeability.
We get the lower peak frequency from the amplification expression, that is when the amplification on the CR output falls for 3 dB compared to the input.

$$fl = 1/(2\pi R_1 C_1)$$

and in this case it is equal to fd=1/(2π*1k1*10μF)=14,47 Hz!
How do we get to the amplification and lower peak frequency expressions?
Our CR input network looks like this:



Output voltage expression

Vout=Vin*R1/(Xc+R1).

From which you get the amplification expression A=Vout/Vin.
A=R1/(1/j ωC1+R1) deriving this equation...
A=1/(1+1/j ωR1C1) If 1/(R1C1) is the lower peak frequency ω_d we get:

$$A=1/(1-j\ \omega_d/\ \omega)$$

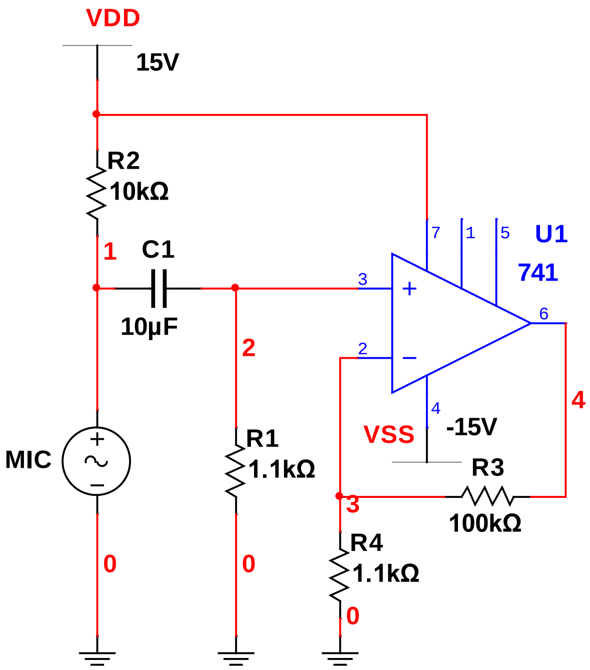
We get the amplification in dB like this:
A(dB)= 20 log A **that is when $\omega = \omega_d$**

A(dB)=20 log( ) = - $\frac{1}{\sqrt{2}}$ **3 dB**

The amplification of the non-invertive OA is determined only by outer elements, that is the resistance ratio as follows: A**=1+R3/R4**

A= 1+100k/1k1 giving us amplification of about **92 times or about 39 dB.**

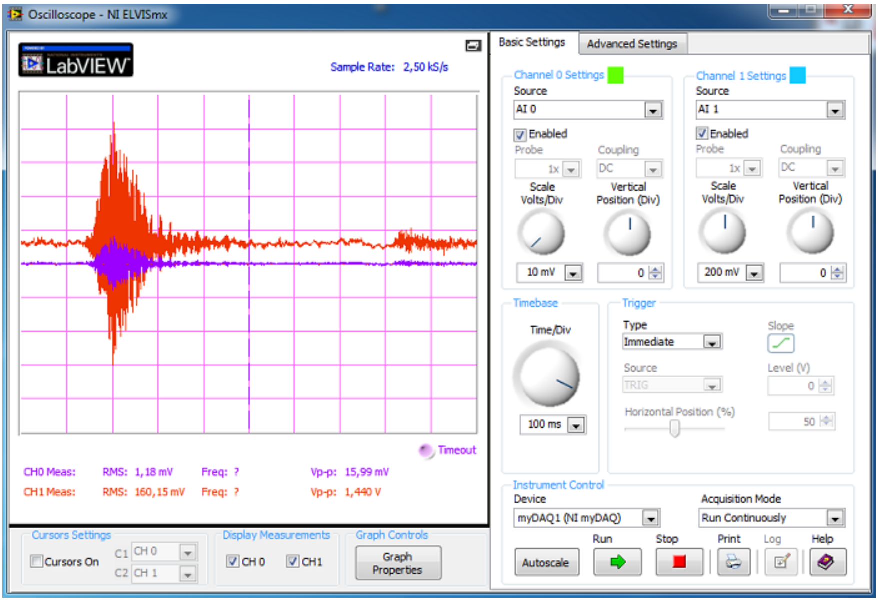
The upper peak frequency of the preamp fu is determined by the characteristics of the OA itself (bandwith=1MHz). Dividing that with the amplification 92 we get the upper peak frequency of 10.87 kHz.

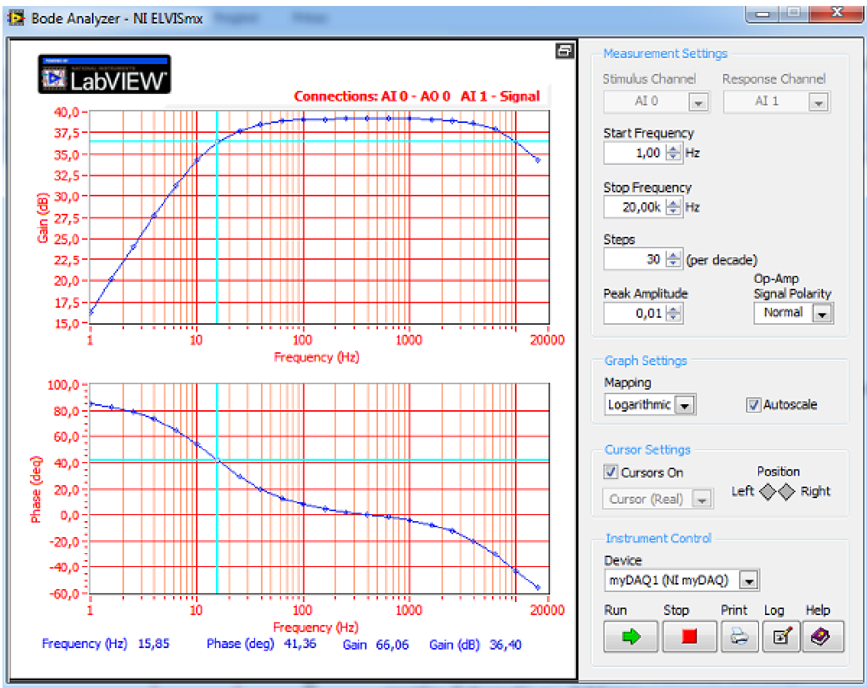


Microphone preamp

Connect the elements according to the schematics. Make sure that the plus pole of the capacitive microphone (red conductor) is connected to the plus of the capacitor, and then place a 10kOhm resistor int hat node and tie it ti +15V.
Try the preamp out and see how it works. Start NI ELVISmx. Start the oscilloscope. Choose two channels. Connect the AI0+ and AI1+ inputs to OA pins 2 and 6, respectively. Connect the AI0- and AI1- inputs to minus (blue line) on the left side of the experimental board. Set the oscilloscope and press RUN.

You will notice that the output is amplified multiple times compared to the input. You probably notice that the output is shifted to plus for about 100mV. Set the drift to zero like described in exercise 4 or simply connect the trimmer 10kOhm between 1 and 5, the slider to -15V and set the signal on channel 2 to 0V. Test the preamplifier with different sounds. Set the time base to 1ms and try again.



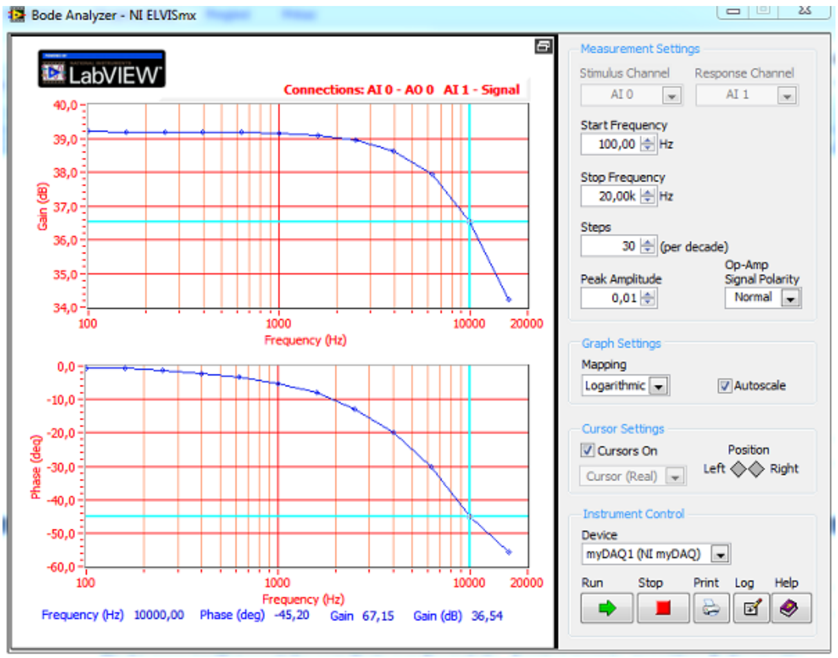


Microphone signal (CH0) and OA output signal (CH1)

Bode's diagram of the microphone preamp – lower peak frequency **15,85 Hz**. To check the theoretical results of the preamp, we can check the peak frequencies with Bode's analyser

Set Bode's analyser to :	Start frequency	1 Hz
	Peak frequency	20 kHz
	Steps per decade	30
	Peak amplitude	0,01 V (10 mV)

Disconnect the capacitive microphone and the resistor. On the plus pole of the capacitor lead the AI0+ and AI0 signals. Connect AI1+ to the output! Run Bode's analyzer and you will get the upper amplitude-phase diagram. Now record the upper peak frequency of the microphone preamp! You only need to set the starting frequency to 100Hz and short circuit the capacitor. You will get the lower diagram.

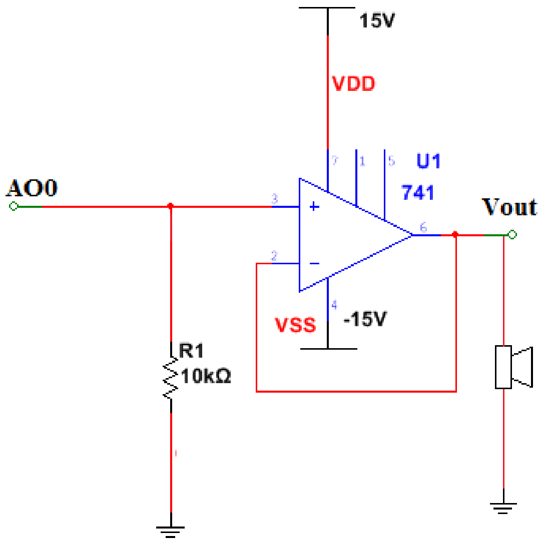


Bode's diagram of the microphone preamp – upper peak frequency **10,85 kHz**

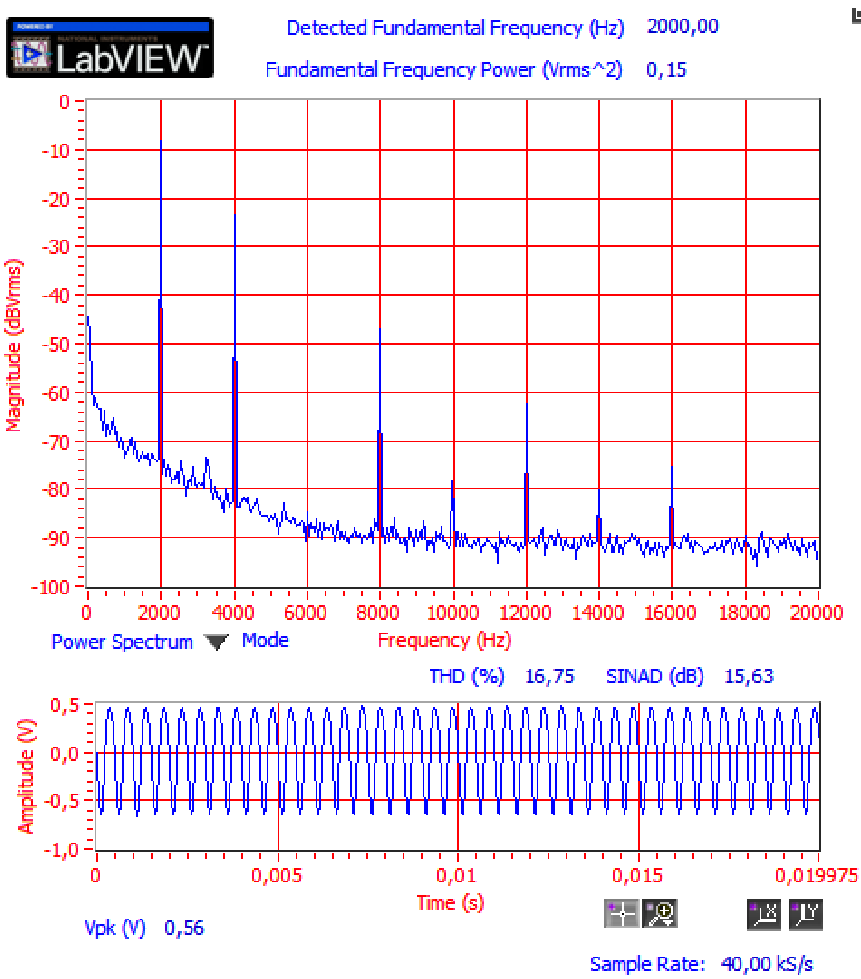
The cursor can measure the upper peak frequency of the microphone preamp fu.
That is the frequency where the amplification drops by 3 dB or to 70.7% of the direct signal compared to them.
Observe the signal phase, too! What is the phase shift at the upper peak frequency?
Excerpt an expression for the amplification of the non-invertive OA given the fact that the currents going to the plus and minus of the OA are equal zero.
What are the differences between theoretical and practical results?

Express your observations :

Using the FGEN function generator we will generate a 2kHz signal and connect it to a speaker. Given the fact that the analogue output of NI myDAQ isn't capable of outputting a strong enough current for a 50 Ohm speaker, we will make a voltage follower with the OA, connecting its output to the speaker. Now the analogue output AO0 is loaded with the 10kOhm resistor, and the OA with the 50Ohm resistance. It is on the following figure.



The amplification of this OA is 1 because the resistor in a feedback loop (R3=0) is replaced with a conductor that short-circuits the output of the OA with the non-invertive input. This assembly is also used as a impedance adjusting assembly (big input resistance, small output resistance), and it is also called a buffer! The analogue output AO0 is connected to the non-invertive of the OA (excerpt 3). On the previous assembly (excerpt 6), that is the microphone preamp, we connect the analogue input AI0+. Now we can observe the harmonic content of the speaker signal. The procedure goes like this: Start NI ELVISmx up and pick the FGEN spectral function generator. We set the amplitude to 0.5V Vpp, and the frequency to 2kHz. Now we start the analyser DSA (Dynamic Signal Analyser) and set its frequency range to 20kHz. Run both devices and get a spectrogram of power with harmonics (see figure)!

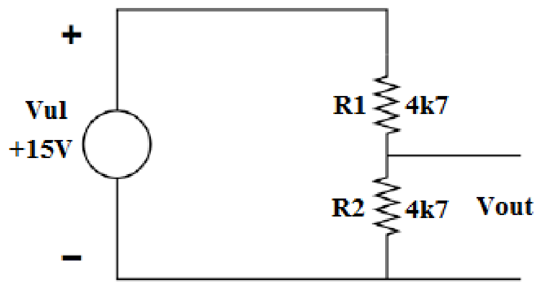


Voltage splitter

In this exercise we will review a voltage splitter and voltage calculations on it. We will see how it works given the load!

Materials and instruments: NI myDAQ
Experimental board
4 1/4W resistors 4k7
Trimmer potentiometer 10 kΩ
Operational amplifier μA 741
Set of conductors

Connect the elements according to the schematics to get a voltage splitter. Because we're using equal resistors it is the assumption that both will have the same voltage.

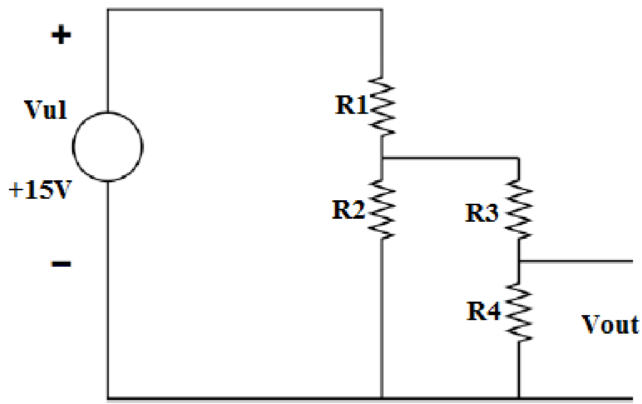


Check the resistors so that you measure every resistor by itself with a special virtual instrument DMM.

Connect the resistors according to the schematics to the voltage source +15V and AGND. Using a digital multimeter measure the voltages on each resistor and the current going through them. Excerpt the expression for the output voltage Vout (using general numbers), calculate Vout and compare it to the measurements.

Express your observations :

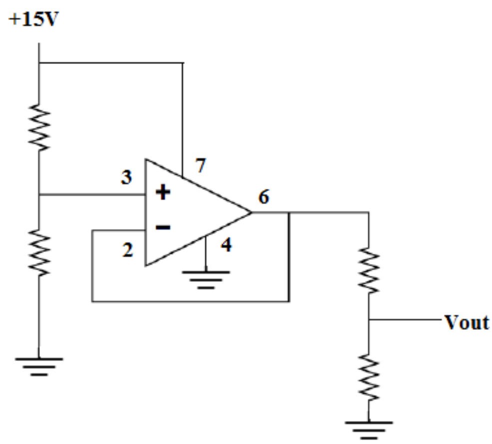
Make a second voltage splitter and connect it to the output of the previous one. Keep in mind that every resistor is the same (4.7 kOhm).



What voltage do you expect on the output? Try to calculate every voltage and current and them measure them with DMM. Why isn't the voltage equal to ¼ of the input voltage? Explain.

Express your observations :

Connect our voltage follower with the OA and make the following schematics. What is the output voltage now? Explain why? Now you must have seen that the OA, which has an equal input and output voltage makes sense and is very important in electronics.



The stepping motor half-step driver

It is necessary to design a driver for the back and forth full step/half step of the unipolar stepping motor!

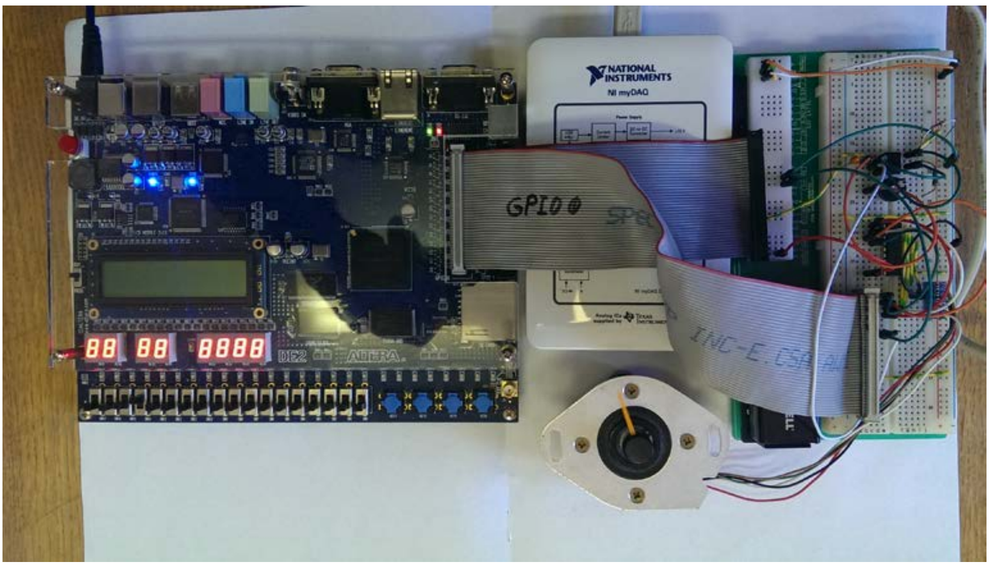
When designing a stepping motor driver, program an FPGA chip Cyclon II EP2C35F672C6 on the Altera DE2 experiment board.

The stepping motor should have a back and forth control mode and operate in full/half step. For the half step, the stepping motor stator is incited as by the following sequence:

1a 1b → 1b → 2a 1b → 2a → 2a 2b → 2b → 1a 2b → 1a

Materials and instruments:

Integrated circuit UDN2981A	1 pc
Integrated circuit NE555	1 pc
Stepping motor MINEBEA17PS-C007-05	1 pc
ALTERA DE-2 experiment board	
Experiment card	
A set of conductors	



The stepping motor full step driver

It is necessary to design a driver for the unipolar stepping motor by using traditional digital electronics integrated circuits. The stepping motor should have a back and forth control mode and operate in full step.

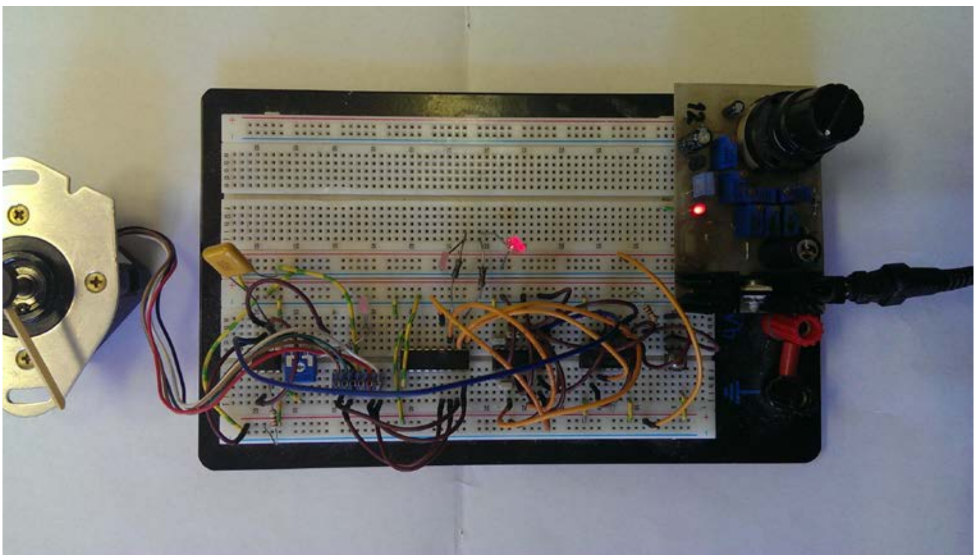
The stepping motor stator is incited as by the following sequence:

1a 1b → 2a 1b → 2a 2b → 1a 2b

When making the design, use a JK flip-flop which has complementary outlets (for example: CD4027).

Materials and instruments:

Integrated circuit CD4027	1 pc
Integrated circuit CD4070	1 pc
Integrated circuit UDN2981A	1 pc
Integrated circuit NE555	1 pc
Stepping motor MINEBEA17PS-C007-05	1 pc
Experiment card	
A set of conductors	



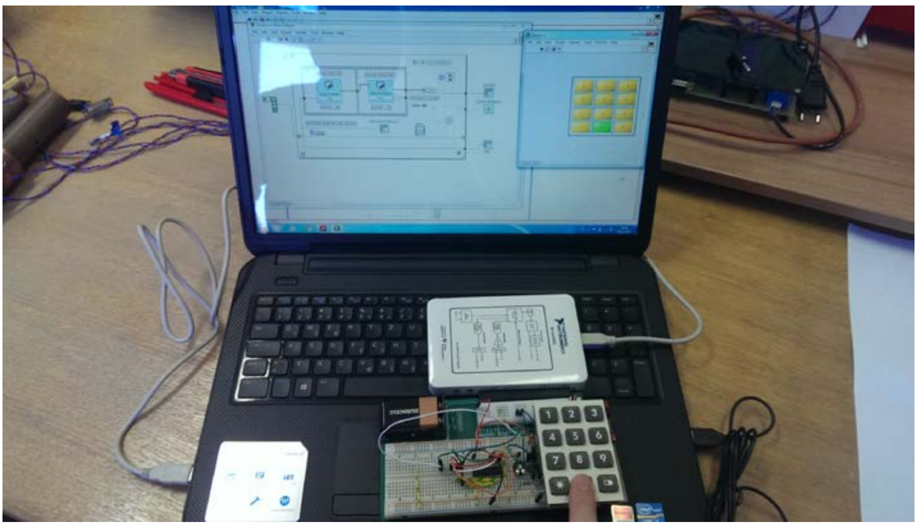
4 x 3 phone dial scanning

This task will teach you how to use the 8-bit port NImyDAQ in order to detect the phone dial keys arranged into a 4 x 3 matrix (4 rows, 3 columns).

The Labview program detects the pressed key and turns into a 7-bit code which contains the row and column address of the pressed key. The 7-bit code is transformed into a Nybble that contains the information about the pressed key, which is then illuminated on the phone dial (PC monitor).

Materials and instruments:

NI my DAQ
4 x 3 phone dial
experiment card
a set of conductors



RealEBook - new kind of feature literature

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We present a control, named Real-e-book, which simulates paging of an ordinary book with amazing realism. The pages of the Real-e-book could contain static contents, like ordinary text or pictures, dynamic contents, like videos and dynamic text, and interactive contents, such as two and three dimensional simulations and applications. The Real-e-book has features for practical and comfortable manipulation as continuous zooming, translating and focusing. It has additional feature like rounded lens, with adjustable size and magnification, fast and automatic paging. Any feature of the Real-e-book works with other features and with any content, whether it is static or dynamic. This gives a user an impression that he is dealing with an ordinary book with "live" pages. One of the way of an expression of an education content, as not seen yet, is by the dynamic text in combination with a simulation, where they are strongly connected in real time. We see the great educational potential of the Real-e-book as a very motivating, time saving educational source, which makes relatively complicated educational processes easier with higher quality of the final result. It could be very convenient replacement for compulsory literature in schools and universities, since it does not break deep habit of paging and reading book, but introduces the power of the multimedia and the interactive simulations.

1. Introduction

Modern educational system at all levels has permanent tendency to increase the information volume, which students have to master. This is way of its improvement which is motivated by the permanent increase of general human knowledge. But this process neglects a substantially important fact: the intellectual capacity of a human is fixed. The result is a decline of the quality and the usefulness of the knowledge students have obtained. Namely, in order to master more and more information, the modern students are more likely to simply memorize facts that they study, instead of connect them into a clear intellectual construction. This kind of knowledge is a short-term one, often sufficient for passing an exam, but has a little impact on the permanent student knowledge.

One way to make the problem of the increasing of the information volume in modern education easier is an improvement of the efficiency of the literature, which students have to use as a source of their knowledge. In the branch of the literature, the official education system is also very conservative. Modern books, which serve as compulsory literature at schools and universities, use basically the same principle as the books did many years ago. Their content is substantially based on a stream of sentences, by which some subjects are explained, and sometimes on pictures, as auxiliary context, which aim is to more deeply explain some details, or illustrate a principle or make the context more realistic.

Not everyone can process the stream of sentences from the books into a useful intellectual construction. That problem is clearly visible in the branches of natural sciences, where the models of natural processes, often based on mathematics and logic, dominate, and where knowledge of the whole has the great advantage over the knowledge of the uncorrelated particular facts.

On the other hand, there are another kinds of sources of the knowledge (literature), based on the modern computer technology, which one can find on the Internet. By this literature, we do not consider so called e-books, which are in fact the PDF documents of the books, written in the classical way, which are dominating on the Internet [1]. We consider video presentation, animations [2] and simulations [3] of some processes or subjects, and on some kind of video games, and even on a combination of an animation synchronized with the narration like those of Khan Academy [4]. All these sources use completely different approach and require different perception of the readers than classical books with the stream of sentences. Our opinion is that they are more efficient and interesting than traditional books, either in the forms of the paper or PDF document. But, they break deep habits of the people to paging and reading the books. Because of that, they are weakly correlated with the classical literature and are not included in the modern official education. They are seen as an additional material to the conventional literature or the literature for leisure time.

In order to combine the filing of a classical book and modern technology, some computer programs (controls) with ability of paging have appeared. Most of them are limited to display text and pictures, and therefore they do not offer any more functionality than classical books. Very recent release of such controls includes some forms of multimedia [5]. But, common characteristics of these controls are limited functionality, where animation of paging is not functional with other feature at the same time, like zooming, focusing, translating or playing multimedia. If multimedia is present, it appears in self-containing program, i.e. outside the book [5]. These and other drawbacks make such controls artificial and relatively unpractical for use.

In this article, we present a control of full realistic simulation of the classical book (named Real-e-book), which in its framework introduces a modern multimedia context (pictures, videos, and animations), simulations (two and three dimensional ones) and other applications, without any limits in its functionality. Our goal was to unify the stream of sentences, the way of presentation of educational matter in classical books, with simulations, animations and other multimedia context in one unit, often in a single page. The full realism of paging of that "virtual book" in any situation with any context gives a reader a filing of reading classical book with pages that become "live". That kind of an evolution of the classical book, enhanced by the modern multimedia technology and applications in one, presents features as not seen before. In the following we present basic feature of the Real-e-book control, and one of its advantage features, we name dynamic text. We based our experiences on two prototypes and one small release in preparation, about electricity in the robotics [6].

2. Technical feature of the Real-e-book

The Real-e-book was written in the Microsoft Windows Presentation Foundation, version 4.0, one of programmer technologies in the .Net framework. It is resolution independent, optimized for resolutions with aspect ratio 16:9.

The animation of paging is very realistic and works with any context, whether it is dynamic, such as videos or two and three dimensional simulation and applications, or static, like pictures or an ordinary text. When the Real-e-book is been paged, dynamic context works regularly on both sites of visible parts of any page at the same time. This feature provides an amazing realism to the Real-e-book. Paging is possible even when any of other features are activated, like zooming, translating, focusing etc.

The Real-e-book works in two modes: normal and deep-zoom mode. In the normal mode, the interaction with content of any page is enabled. This is a mode in which user works most of the time. In the deep-zoom mode, a user can focus a part of the book and zoom it at the same time by double click of the focus point. Holding left mouse button and moving the mouse enable the continuous translation of the book. Continuous zooming is carried out by middle mouse button.

The Real-e-book has a lens of a rounded shape. The magnification and radius of the lens is adjustable. The lens is fully realistic, i.e. it works in any situation and magnifies any content including dynamic ones, like videos or two or three dimensional simulations and applications. The lens works even when the Real-e-book is magnified via the deep-zoom mode, where the magnification of the lens and magnification achieved by the deep-zoom mode are multiplied.

There is automatic paging mode with an adjustment of the time of the presentation of the page. The automatic paging works in both directions, from the beginning to the end and vice versa. It

could be stopped and the direction of paging can be changed at any time. This feature gives ability the Real-e-book to be also a presentation control.
The manual fast paging is possible by either double click of any corner of a page or by turning a round button, styled like volume buttons in a classical stereo system. The sensitivity of the button can be adjusted. A user can see the number of presented pages and the total number of the pages.

All features of the Real-e-book is accessible by the special menu and the standard Windows context menu. The Deep-zoom mode is accessible by holding the Crtl key. The Real-e-book works in a widow like any ordinary Windows program, and in full screen mode, where the book fills whole screen without edges.

Fig. 1. The figure shows a moment of turning a page, where two different videos (Space Shuttle and a waterfall) play on both sites. The videos follow naturally the curvature of the page. In the page behind is a dynamic transformation of a picture (yellow color), which also plays. Everything is highly realistic, so users have an impression that they are working with an ordinary book with “live” pages.

3. Dynamic text and simulations

One of the features of the Real-e-book, which is not possible in classical books is dynamic text. It comes along with a simulation, either two or three-dimensional one. It is particularly very useful when the simulation and the corresponding dynamic text are on the same page. We explain the dynamic text assuming the physics as the education content.
The dynamic text describes the content (physics) of the underlying simulation, with the reduced number of sentences, but in the traditional way as in the classical books. As the user changes the simulation, the dynamic text is changed accordingly, and it always expresses the current state of the simulation. Since the simulation can take a lot of different states, there are a lot of different versions of the dynamic text accordingly.
The dynamic text with the simulation connected has an important pedagogical impact. Firstly, it converts almost each page into a small interactive lab. Users can change the simulation according to their wishes, in order to see effects of processes, which are considered, and they become prompt information and explanations by the dynamic text. On that way the users become investigators of the content they study.
Secondly, the simulation and the dynamic text have a magic attraction of video games, which are very important and motivating for young generation. This is particularly important for those individuals, who do not like physics, math, or any other particular content, but they will deal with that content in the Real-e-book, because of their love of the computer games.

4. Conclusions

The Real-e-book is an amazing realistic simulation of a classical book, which introduces multimedia and two or three dimensional simulations and applications on its pages. It is very practical for use since it can be magnified, translated, and focused without any limitations. Any feature of the Real-e-book works with other features at the same time and with any content, whether it is static, like ordinary text or pictures, or dynamic, like videos and dynamic-text, or interactive like, simulations and other applications. It enables a lot of different ways of presentation of an educational content, from the way of classical books, to the way of multimedia content as seen on the internet. It also allows us to present an educational content on ways as not seen before. One of them is a use of a combination of the dynamic text and a simulation, which are connected in real time. That approach is enhancement of traditional presentation by stream of sentences, as in classical books, which cloud be now changed by interaction of a user with the simulation.

Dynamic texts width simulations also introduce a magic attraction of computer games, which is strongly motivating content for young users. The combination of the traditional book and the power of multimedia and simulations could be a solution of the problem of large volume information in the modern official education. It would have to be accessible by the conservative official education system. We believe that the Real-e-book could also lower an intellectual threshold required for mastering some relatively complicated subjects.

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Smoke display

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Nikola Poljak, Prirodoslovno-matematički fakultet, Zagreb

We hereby present our current development of a smoke display, an apparatus capable of producing characaters made of stage smoke. The display uses micro-controlled amplified signals powering a series of push-type solenoids which then create in-air smoke vortices. The article describes the mode of operation of the display as well as planned refinements.

1. Introduction

Modern society utilizes various kinds of displays. Examples one can think of range from simple displays like airport billboards and DVD displays to complex systems like LCDs. Media used to display information is mostly electronical in nature, but sometimes also includes alternatives, like a water display [1]. In this setup, we have decided to use smoke as the medium and make a display which uses moving smoke vertices ("puffs" in layman terms) to display characters and symbols.

2. Experimental realization

The smoke display uses 7 cylindrical tubes to produce symbols. All the tubes are identical and each of them can produce a single smoke vertex. The tubes are stacked vertically, so that the top tube always produces the top part of the symbol and vice versa. This is analogous to moving letters displays which are utilized, for example, in trams, where letters are made of dots arranged in vertical order, moving in the horizontal direction. All the tubes are connected to a smoke inlet and are filled with smoke by means of a typical stage smoke machine. On one end (the display end) of the tube there is a circular aperture, which creates a vertex when smoke is forced through it. On the other end (the driver end) of the tube there is a solenoid, which produces the necessary push to the smoke. The solenoids are driven by a micro-controlled system, whose schematic is given on Fig.1.

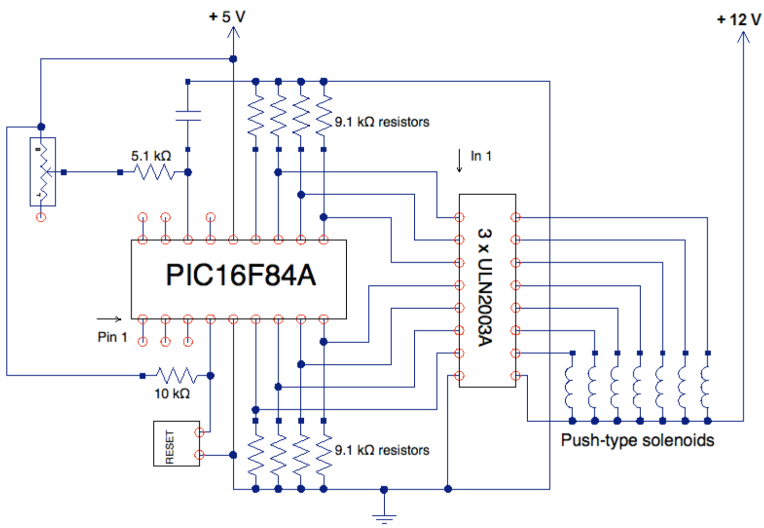

Fig. 1. The schematic display of the micro-controller system. Specific schematics for PIC16F84A and ULN2003A can be found in [2] and [3].

As one can see from the schematic, the smoke display is driven by a PIC 16F84A microcontroller. This is an 18-pin enhanced 8-bit microcontroller, which takes in a clocking signal and provides a set of instructions (signals) on its output pins. The PIC program memory contains 1K (1024) instructions, which can be pre-programmed with a special external board. A more detailed description of the controller can be found in [2]. The clocking signal provided to the PIC is achieved by means of an RC circuit. The circuit is made with a capacitor and a knob potentiometer, thus giving the user the option of externally modifying the clock frequency, and thus changing the display speed. The controller also has an input timer reset signal, connected to a simple button placed on the board. There are 7 output signals programmed and sent from the PIC, each corresponding to one solenoid.

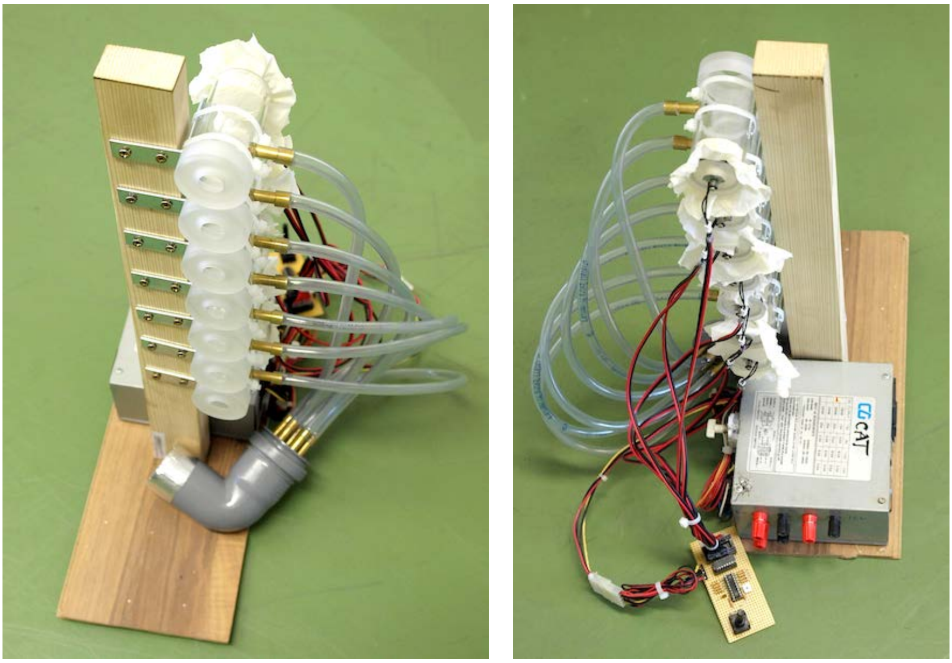

Fig. 2. The front (left) and the back (right) views of the apparatus. On the left one can have a clear view of the smoke inlet system and on the right one can see the microcontroller board and the power supply.

The output signals from the PIC are fed to a transistor array, which amplifies the signals so they are powerful enough to drive the solenoids. The transistor array chosen to do this task is made of ULN2003A 7 channel high-voltage, high-current Darlington arrays. Each of these arrays consists of seven n-p-n Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The pairs can be paralleled for higher current capacity, which was done in this setup, where 3 arrays were used. Detailed information regarding ULN2003A can be found in [3].

Finally, the whole driver board is powered with a modified computer power supply. These power supplies can typically sustain 300W of power and give outputs of 5, 12 and 24V. The max. instantaneous power expenditure in this setup is estimated to be around 125W, assuming a full 7-channel inductive load. The power supply, the board, the cylinder stack with the solenoids and the gas system are mounted on a single platform, making the system easily transferrable.

3. Future developments

One can easily imagine the applications of this device in the entertainment industry, such as in rock or pop concerts, as well as for educational purposes. A refinement intended for the setup is an addition of low-powered air-fans, to create a steady, laminar flow of air, which should aid the horizontal movement of smoke vortices. One can also think of scaling the entire system up, which shouldn't be difficult to realize with additional Darlington arrays connected in parallel, provided the power requirements could be met.

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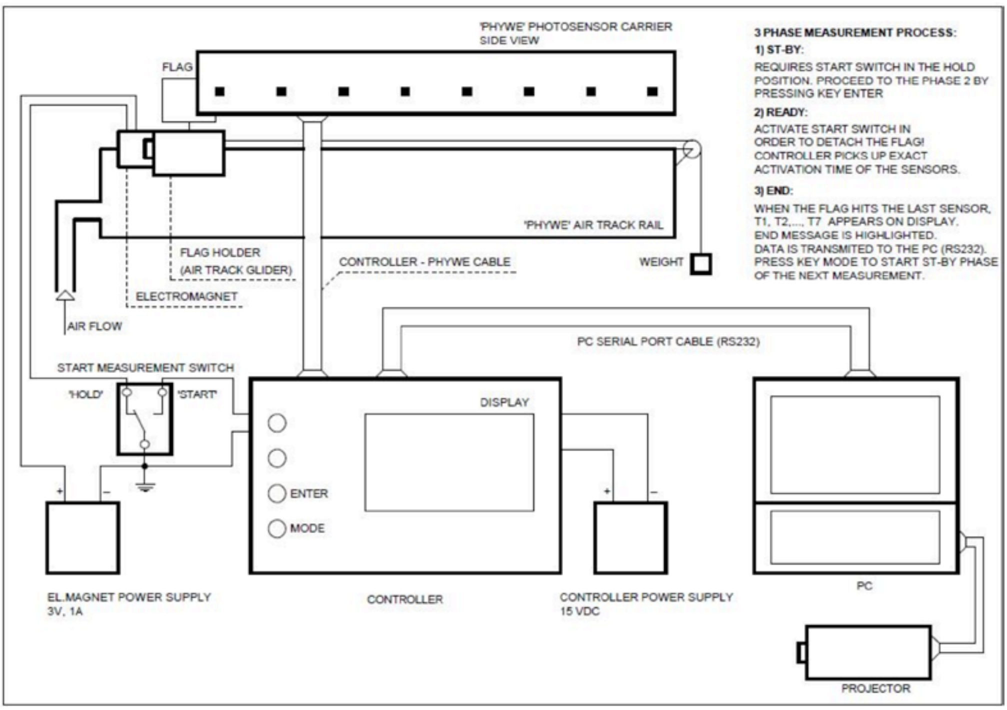
PHYWE system improvements for the motion examination along the straight line

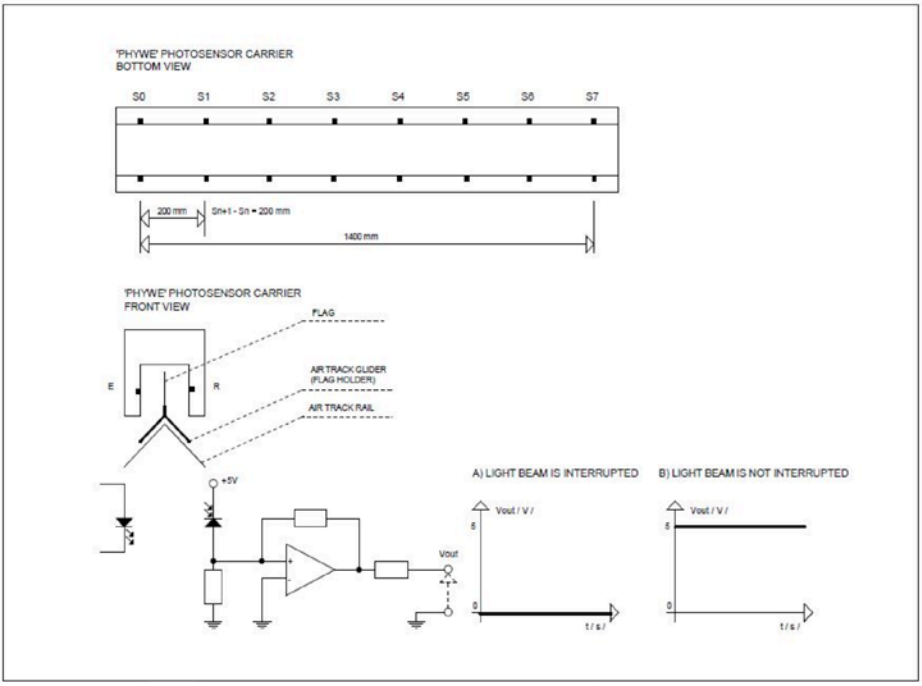
1. Controller for the time measurement (timer) and transmition of the measurement data to the PC.
2. PC program for graphical presentation of the measurement.

Time measurement is performed within timer interrupt routine each100 microseconds which gives accuracy of the 0,0001 seconds. PC program presents distance-time, velocity-time and acceleration-time graphical diagrams visible in the whole classroom by means of connected projector.

PHYWE system provides all the components needed for the experiment. Cancelation of the friction between the 'air track glider' (flag holder) and the 'air track rail' surface is accomplished by air blowing inside the 'air track rail' and air exit through the small, evenly distributed holes on the surface. Such a system is convenient to explore:

1. Uniform linear motion (constant velocity).
2. Uniformly accelerated motion.
3. Newton's second law.




'PHYWE' PHOTOSENSOR CARRIER
BOTTOM VIEW
S0
S1
S2
S3
S4
S5
S6
S7
200 mm
Sn+1 - Sn = 200 mm
1400 mm
'PHYWE' PHOTOSENSOR CARRIER
FRONT VIEW
FLAG
AIR TRACK GLIDER
(FLAG HOLDER)
AIR TRACK RAIL
E
R
+5V
Vout
A) LIGHT BEAM IS INTERRUPTED
B) LIGHT BEAM IS NOT INTERRUPTED
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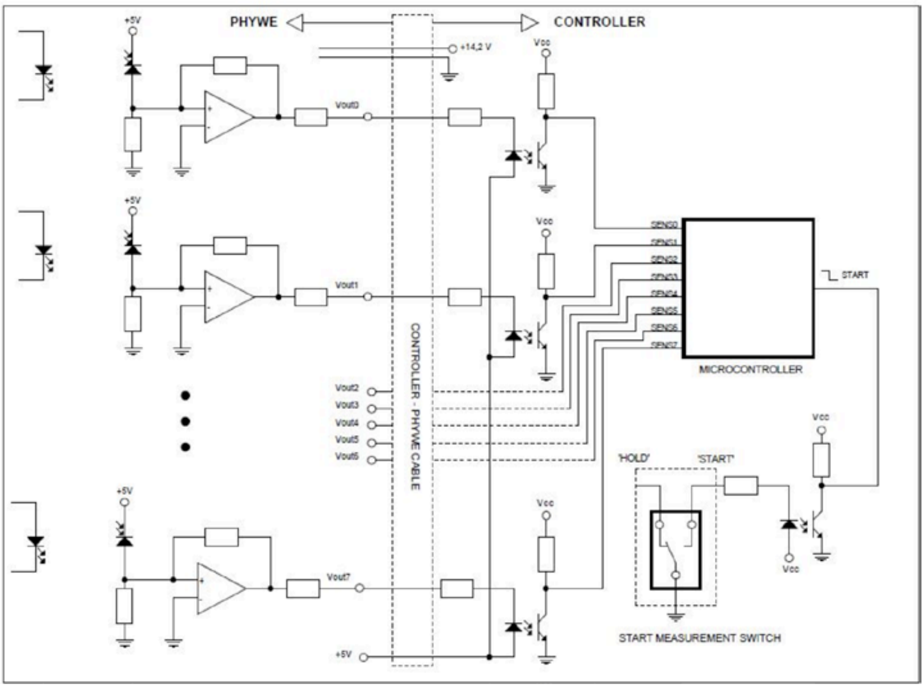
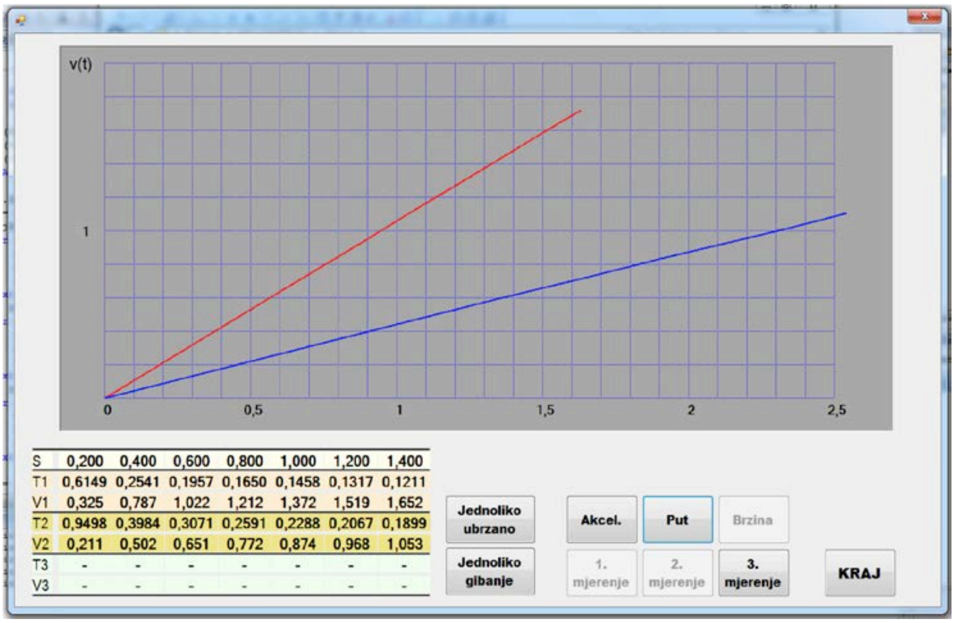
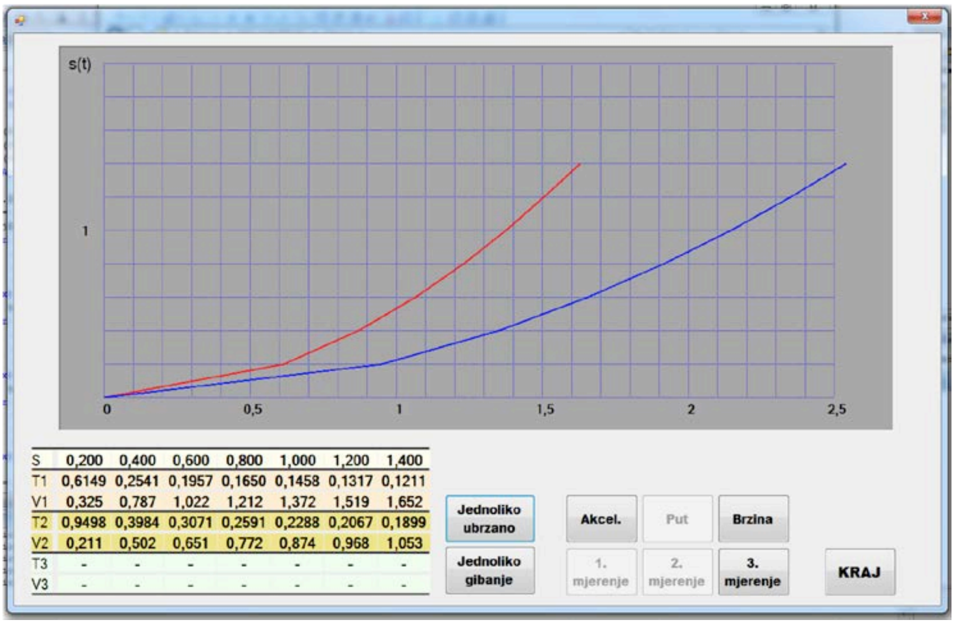
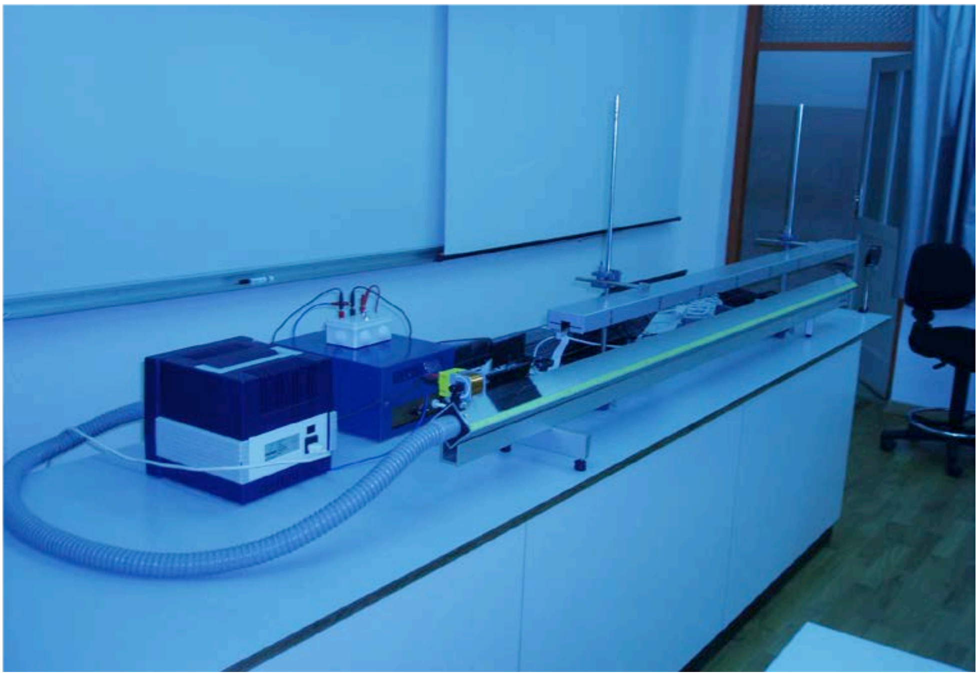
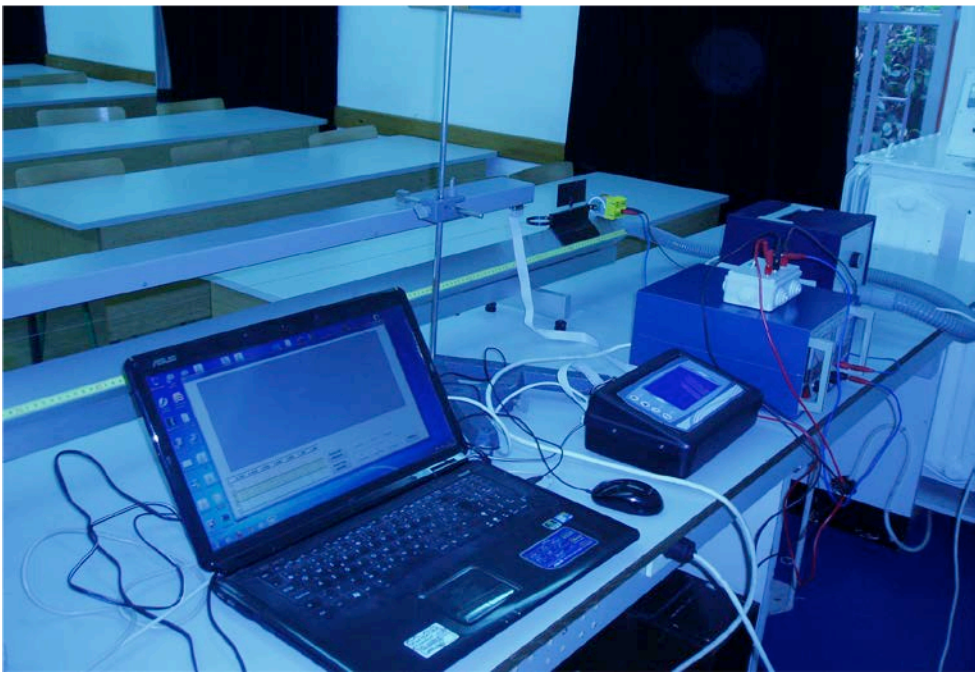

PHYWE
CONTROLLER
+5V
+14,2 V
Vcc
Vout0
Vout1
Vout2
Vout3
Vout4
Vout5
Vout6
Vout7
CONTROLLER - PHYWE CABLE
MICROCONTROLLER
START
'HOLD'
'START'
START MEASUREMENT SWITCH

Controller is connected to the PC's serial port. Measurement data (T1, T2,...,T7) are processed and displayed on the screen of the PC as a table of the measurements and as a time graph of the velocity, distance and acceleration. When the PC is connected to the beamer, Fig.1 and Fig.2 (below this text) can be displayed in the classroom immediately after the experiment is completed. Fig. 1 represents accelerated movement caused by two different weights (velocity as a function of the time). Fig. 3. and Fig. 4. (next page) show the experimental setup in the lab.









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