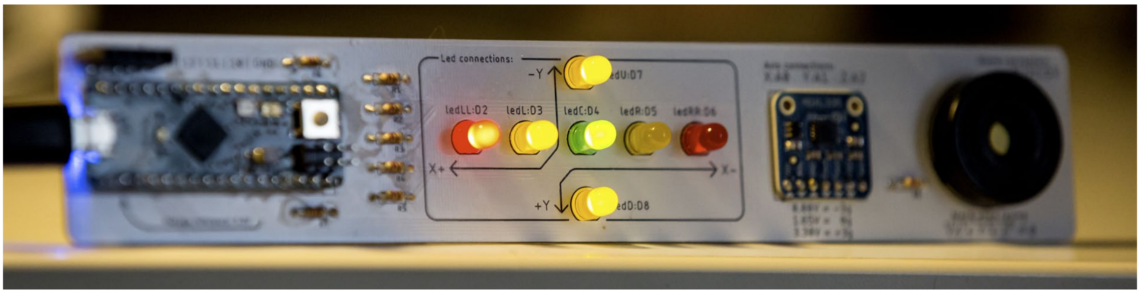
DIGITIZING PRODUCTS:
CREATING DEMONSTRATORS
FOR FUTURE EDUCATION

digi demo

How the accelerometer works

Demonstrator classification and documentation



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Project consortium

UCN

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Dissemination level

Code	Access granted to
PU	Public
PP	Restricted to other programme participants (including the Commission Services)
CO	Confidential, only for members of the consortium (including the Commission Services)

Legal Disclaimer

About the DigiDemo project

Environmental challenges and digital transformation are two of the main drivers changing the world and the way business will be is done in the future. Therefore, it is essential to enable future employees to address these drivers. The skills and competences needed to develop digitalized products and awareness of the environmental challenges are therefore crucial for the European workforce and industry to continue being competitive in a future green economy and to maintain jobs across Europe.

The DigiDemo project addresses these challenges by developing demonstrators especially for higher education allowing to improve mainly mechanical engineering studies by integrating skills and competences allowing them to understand, develop and commercialise connected products. The results will be publicly available and can be used by every institution interested in integrating this type of training in their cursus.

Content

Document authors

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Revision history

Version	Date	Author(s)	Description
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1.1	2023-04-17	Patrick Grønlund	First release
1.1			
1.2			
1.3			

Document status

Status description
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Abbreviations

ESTA	ESTA Belfort (France)
FHV	Fachhochschule Vorarlberg (Austria)
FIV	Fagskolen i Viken (Norway)
UCN	University College Nordjylland (Danmark)
UEMR	Universitatea "Eftimie Murgu" din Resita (Romania)
PCB	Printed circuit board
LED	Light emitting diode

List of figures

Har ikke fundet nogen tekst til listen over figurer.

List of tables

1 Elements of a Demonstrator

The purpose of this document is to describe the deliveries, scope, and responsibilities of developing an accelerometer. The document will also describe the technical, functional, and architectural requirements.

The goal is to develop and build a physical demonstrator to meet learnings objectives about accelerometer, its operation and structure, including some simple physics to understand gravity and acceleration. The idea is to develop kits that anyone can easily use during hands-on training.

The kit should contain 26 "acceleration education set’s":

The idea is that in the box in which this is to be placed, there is also to be a memory stick with a complete layout, so that anyone can use this by only reading through for preparation to the task.

Then we can use it in teaching, gathering, and if we are going out and travelling. Won't take up much space.

1.1 Overview

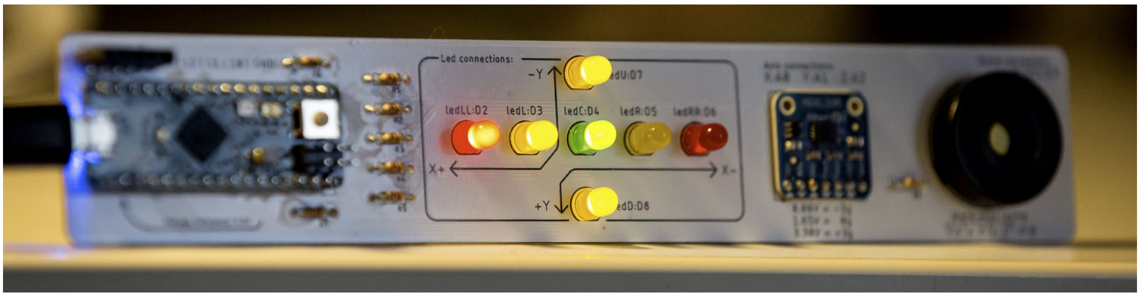
The key properties of the focus project are:

Table 1: Specification of key properties of the focus project

Key Property	Value
EQF level	5 (Technician)
Year of study	2
Domain	Mechatronics
Objective	Hands-on
Workload	Depending on setup
Keywords	MCU Programming, microcontroller, accelerometers

The demonstrator is suited for education on vocational college level. The demonstrator, shown below allows for teaching within the following subjects:

- Learn to use the development kit and how to read information in it.
- Accelerometer as à component how does it work
- Use a different microcontroller, but the same programming language. So that they can see that they have learned more than they think, and that their possibilities are greater than so far shown.
- Change reference voltages on a Arduino Micro
- Analogue reading
- A little dive into physics and programming based on reality. Programmers are supposed to become problem solvers, so now the knowledge they have accumulated can finally be used in the real world.
- Some simple trigonometry for calculating angles.
- Use formula for drop detection.
- Can also create a set that uses external functions, then it can also be used at the end against the day classes that have progressed further. A simple way to get reuse of time used.



Technical requirements

- Educational kit
- USB micro cable
- Arduino IDE

Functional requirements

1.2 Description of fulfilment of keywords/characteristics

Table 2: Description of fulfilment of demonstrator characteristics for the focus project

Characteristic	Description
Teaching improvement	The demonstrator will improve teaching, by using a physical demonstrator to meet learnings objectives about accelerometer, its operation and structure, including some simple physics to understand gravity and acceleration of a well-known object. When the physics and understanding of the accelerometer is in place, the students will be able to make: - Detect witch orientation the PCB is held in - Make electronic level - Detect when the PCB is dropped - Calculate the angle of the PCB - Control a 3D-model on the computer by moving the PCB
Sustainability awareness	In this project the sustainability awareness is seen in a broader context, relating to World goal 4, Quality education. Though the technology can be used to make better sustainability in a lot of industries. Eg. Lets say there is a mechanical part that usually wears out. You have a couple of choices. 1. Wait until the part goes bad and stop production to fix it. 2. Changing it before it needs fixing, and wasting parts. 3. Monitor the vibrations with an accelerometer and have a computer system tell you when it needs to be changed.
Replicability	The demonstrator will be replicable, as all of the hardware will be based on readily available modules, and further instructions on system fitting will be provided.

Characteristic	Description
Industry needs	**Automotive industry:** -Crash detection and deployment of the air bag **Everyday electronics:** -Hard drive protection -Rotate screen -Image stabilization **Mechanical Industry:** -Vibration detection -Wear detection **Aircraft and Defense:** -Navigation -Auxiliary systems for guiding missiles -Encumbrance detection
Interdisciplinarity	The demonstrator will be interdisciplinary, covering the following fields: Programming, electronics, math, physics, mechanical

1.3 Classification according to the dimensions

Table 3: Classification of the focus project according to the dimensions

Dimension	Property	Value
Value chain	development	☑
	production	☑
	sales	☐
	after-sales-support	☐
	end-of-life	☐
Chain of technology	mechanical structure	☑
	sensors	☑
	electronic circuits	☑
	edge device	☐

Dimension	Property	Value
	data transmission	
	cloud	
Sustainability	energy reduction	
	material reduction	☐
	better materials	☐
	better production	☐
	reparability	☐
	recycling	☐
Physicality	physical setup	☑
	simulation	☐
Degree of student freedom	demonstrated	☑
	guided	☑
	coached	☑
	autonomous	☑
Transportability	fixed	☐
	transportable	☐
	portable	☑
Costs (implementation)	EUR	1213
Costs (operation)	EUR	NA
Workload (implementation)	Hours	
Workload (operation)	Hours	8
Size	m	< 1
Weight	kg	0,5-2
Special requests	no/yes, if yes: which	no

1.4 Educational information

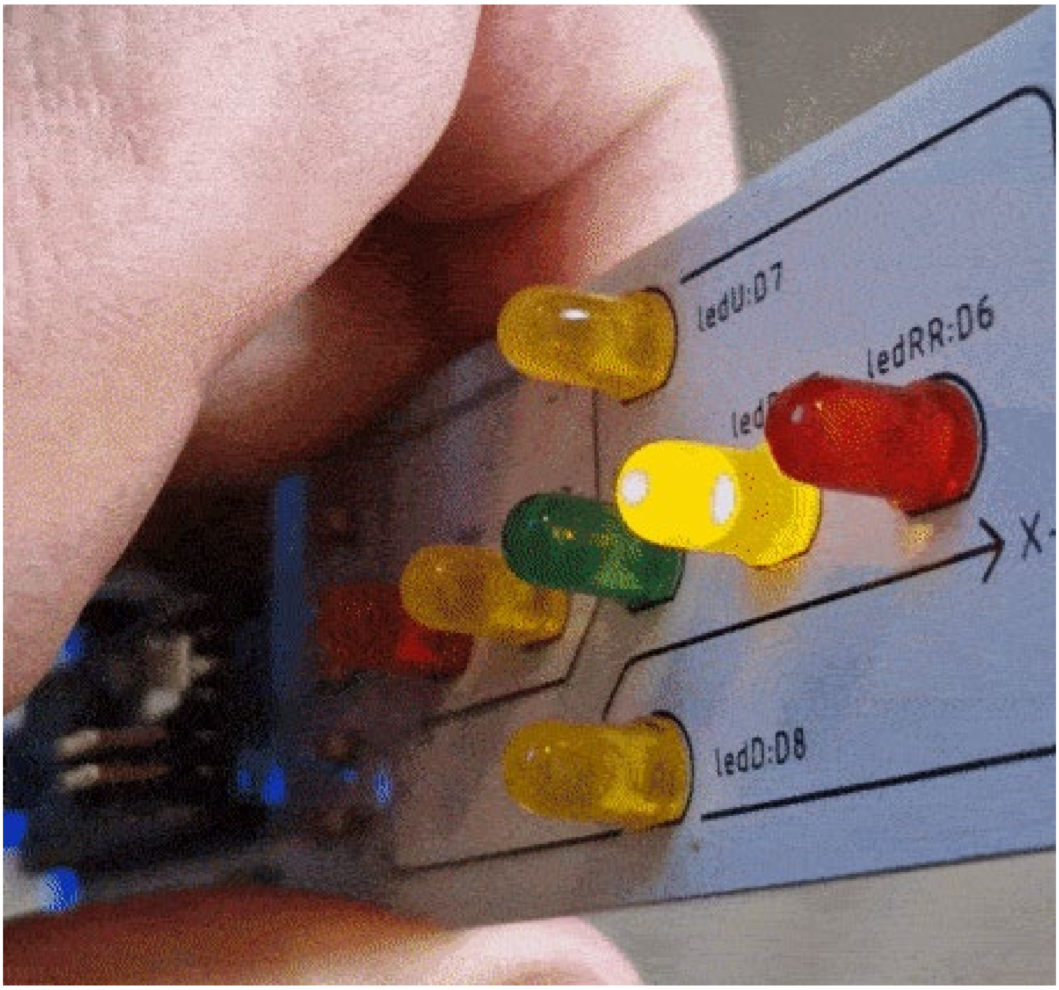
Course content

First the students will learn how to use and read the information on the PCB for the accelerometer kit.
Then the students will learn what acceleration means, the inner workings of a MEMS accelerometer and how it's affected by gravity.

All this is done through presentation and collaborative work between the students.

When the basic program is made for the acceleration kit, the students will embark on four assignments the expand their knowledge of different use cases for the accelerometer.

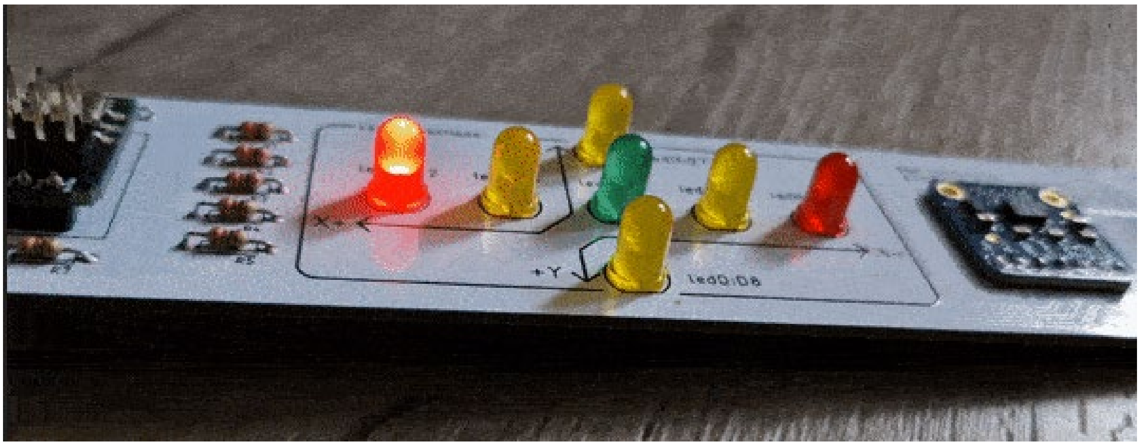
First assignment: Identifying orientation
How does your smartphone know which way is up, when it should be in portrait or landscape mode? This is due to an accelerometer, and the students must now use the analog data from the accelerometer to identify what side of the "development kit" is pointing up.
There are four yellow LED's on the board they will use to indicate which side is pointing up by illuminating only the LED that is pointing up.



Second assignment: Electronic level

The students will make control structures in their code reacting on the different gravitational pull on the X-axis of the accelerometer. With this value you can figure out if the PCB is tilted or is in level.

If the PCB sits on the table the center green led should be illuminated, the more you tilt the PCB the further away the "bouble" will move. Just like a mechanical level.



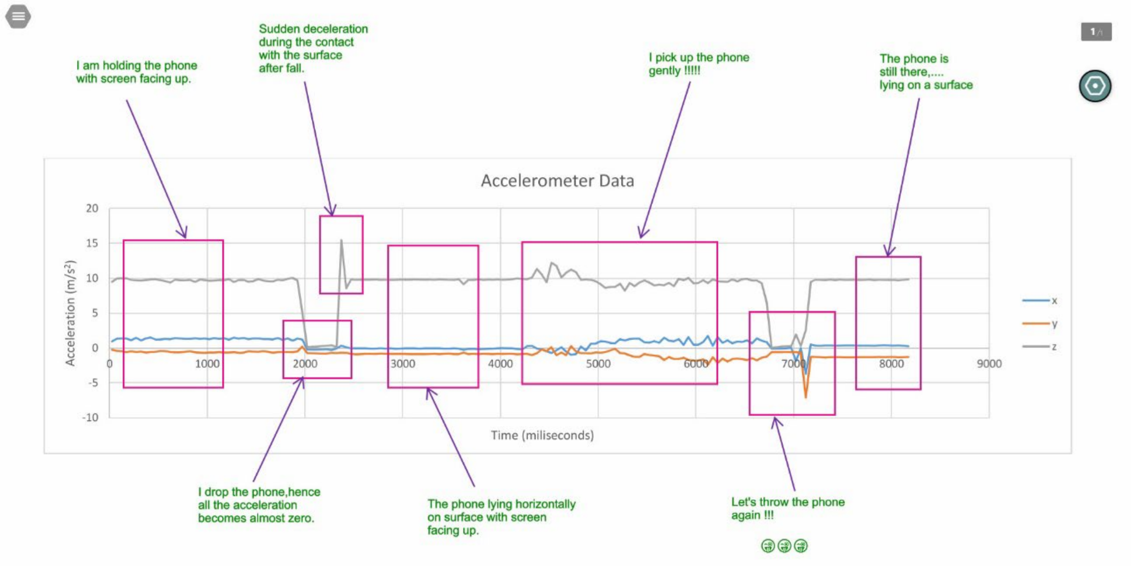
Third assignment: Drop detection

When an object is falling the total acceleration of the PCB will theoretically be zero.
the students must figure out how to implement a measurement for total acceleration, and make a decision when this measurement is close to zero.

When the PCB is falling they should program the speaker to give an alarm.

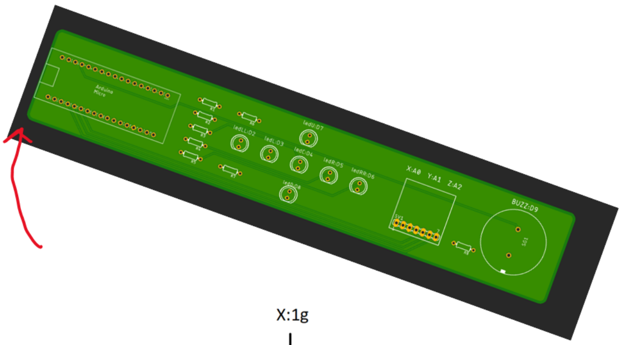
They are given the formula below, and a graph showing how the acceleration for the three axis move in different circumstances for a phone.

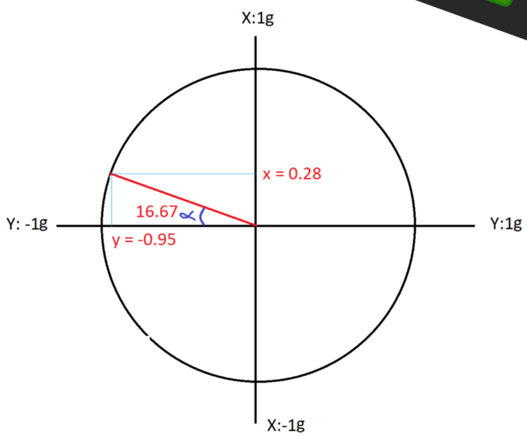
$$Total\ acceleration = \sqrt{{X_{Accel}}^2 + {Y_{Accel}}^2 + {Z_{Accel}}^2}$$



Forth assignment: Measure angle

We can use the change in gravitational pull on the X-axis and the Y-axis to measure at what angle the PCB is held in.
Here the students must figure out how to implement a math library, to get access to arctangens to calculate the angle.

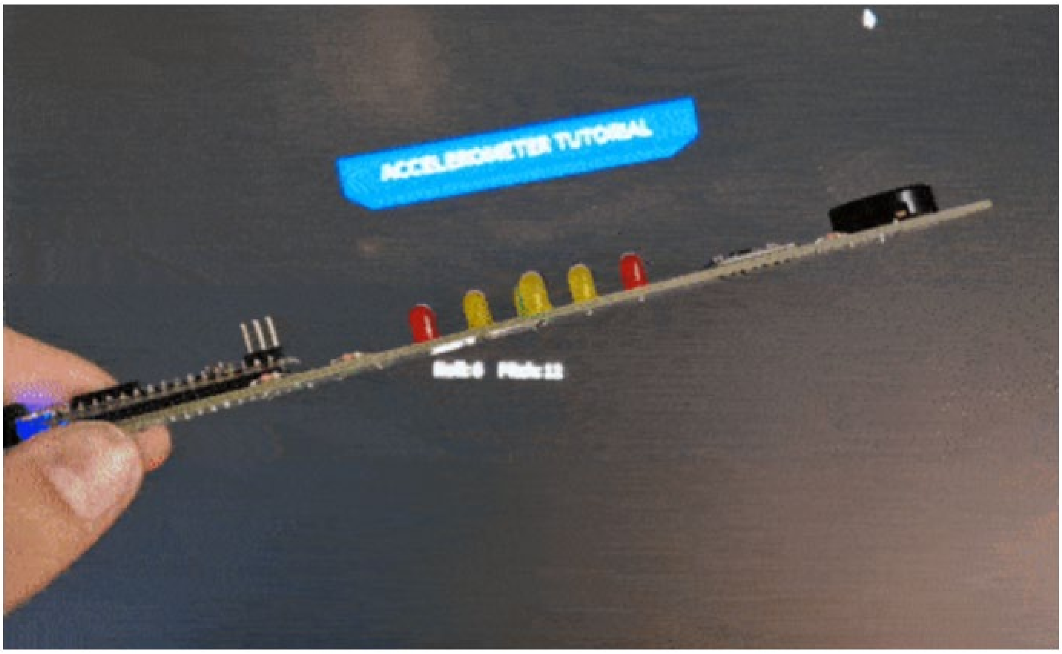




Fifth assignment: Control a 3D-Model

In this assignment the students will test out an already written Arduino Code, and a processing code. They will upload a sketch to the Arduino that has more advanced math and filters than previously used. And install Processing with a program that launches a 3D model of a cube.

They can now move the PCB and see that the cube on the screen also moves.



This assignment is included to show that we also can use the accelerometer to control a PC or perhaps a robot. The math and programming is a bit harder on this example, so its better to just let the students try it out to keep them inspired and not to frustrated.

Intended Learning Outcomes

The demonstrator is thought to be used over several teaching sessions with exercises. It is expected that the student after the demonstrator sessions session can:

- Explain and use Accelerometer as à component, we take a look at the inner workings of the accelerometer.
- Use a different microcontroller, but the same programming language. So that they can see that they have learned more than they think, and that their possibilities are greater than so far shown.
- How to change reference voltages for an analogue to digital converter
- Analogue reading of the accelerometer.
- A little dive into physics and programming based on reality. Programmers are supposed to become problem solvers, so now the knowledge they have accumulated can finally be used in the real world.
- Some simple trigonometry for calculating vectors.
- Can also create a set that uses external functions, then it can also be used at the end against the day classes that have progressed further. A simple way to get reuse of time used.

Lecture on:

- Accelerometer kit, how to read the information on the PCB
- About the accelerometer, its operation and structure, including some simple physics as they have to understand gravity and acceleration.
    - Task 1: Change analogue reference voltage, and calibrate the sensor.
    - Task 2: First assignment: Identifying orientation
    - Task 3: Electronic level
    - Task 4: Drop detection
    - Task 5: Measure angle
    - Task 6: Control a 3D-Model

Planned learning activities and teaching methods

It all starts of by introducing the students to the accelerometer kit, and how to read the information on the card. They get 45 minutes to create a test code for the card to get familiar with the IO.
There will then be a lecture on MEMS accelerometer and some simple physics to prepare them for the assignments to come. They will then be presented with 5 assignments they will need to complete with the knowledge they got from the lecture, and with some hits that are written with the assignments.

Assessment methods and criteria

Recommended or required reading

Mode of delivery (face-to-face, distance learning)

Face-to-face

1.5 Organizational information

The following requirements apply

- Project duration. *The optimal time frame (for instance in weeks) for the project shall be estimated.*
  8 hours are recommended for this lecture.
- Team size. *The number of student team members is useful.*
  26 students can do this at the same time. Would recommend having two teachers.
- Preparatory and follow-up activities. *If this type of activities is needed prior to the use of the demonstrator, or after the project has been finished, these shall be listed.*
  The teacher should calculate to use 8 hours to prepare, test all the programs and to understand them.

This demonstrator uses the following hardware:

Component	**Function**
Accelerometer kit	Is used to test and program the accelerometer with other IO connected.

1.6 Description of the technology and the setup

Bill of Materials

The following table will outline the materials needed to produce 26 units of the demonstrator.

Price is for 26 acelerometer kits						
Quantity (Unit)		Description	Price (per Unit)		Price (total)	Link to part
6,5	pc	Female headder	1,3	€/pc	8,45	https://www.elfadistrelec.no/en/wr
208	pc	220 Ohm resistor	0,012	€/pc	2,496	https://www.elfadistrelec.no/no/ku
26	pc	Piezo electric speaker	0,56	€/pc	14,56	https://www.elfadistrelec.no/no/pi
104	pc	5mm yellow led	0,14	€/pc	14,56	https://www.elfadistrelec.no/no/le
52	pc	5mm red led	0,14	€/pc	7,28	https://www.elfadistrelec.no/no/le
26	pc	5mm green led	0,14	€/pc	3,64	https://www.elfadistrelec.no/no/le
26	pc	ADXL335 accelerometer	14,73	€/pc	382,98	https://www.elfadistrelec.no/no/ad
36	pc	Arduino micro	18,88	€/pc	679,68	https://www.elfadistrelec.no/no/mi
36	pc	USB micro cable 2n	2,28	€/pc	82,08	https://www.elfadistrelec.no/no/us
36	pc	PCB	0,5	€/pc	18	
					€ 1 213,73	**total**
					€ 46,68	**pr unit**

Table 4: Classification of the focus project according to the dimensions

2 References