

# Format Portfolio Smart Solutions Semester

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Name client:	REV'IT! Sport International B.V. - Jorrit Memel
Name tutor:	Jenny Hesse
Names group members:	Isabel Wesselink (434129) Femke Visser(435542) Le Van Hoang Minh (467475)
Project name:	Testing device membrane fabrics for motercycling
Project number:	L.26195

A) *What does my client think of our delivered results?*  
[Feedback from REV'IT](#)

B) *What does my tutor think of my contribution to the group process?*  
[Feedback tutor: Jenny Hesse](#)

C) *What do my group members think of my contribution to the group process and the results?*  
[Feedback group members](#)

Please add the pieces of evidence to this document.

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## Table of Contents

1. Words List .....	4
2. Feedback from tutor .....	5
3. Feedback from the company: REVI'T .....	6
3.1 Midterm Feedback.....	6
3.2 Final Feedback .....	7
4. Feedback from my group members .....	8
5. Saxion Festival Smart Solutions Semester .....	9
6. The assignment.....	11
6.1 Introduction organization .....	11
6.2 Assignment / Project goals .....	11
6.3 Requirements .....	11
6.4 What do we expect?.....	12
7. Final Product.....	13
8. Assessment rubic .....	15
9. Project Plan .....	23
10. Technical Research .....	42
11. Drilling wholes .....	63
12. Software Development.....	64
13. Software for firmware .....	67
14. Device .....	96
14.1 First Prototype .....	96
14.2 Second Prototype .....	96
14.3 Final Prototype / Final Device.....	97
15. Laser.....	99
16. Interview.....	100
17. Midterm presentation .....	101
18. Last Presentation REVIT .....	104
19. Product Manual .....	113
20. Testing.....	121
20.1 Testing final prototype – REV'IT! & Intrepid (21/01/2020 – 22/01/2020) .....	123
20.2 Graph testing final prototype – REV'IT! & Intrepid (04/01/20 – 09/01/20).....	128
21. Problem solving .....	129
21.1 Accuracy problem solving.....	129



21.2 Burned sensors .....	129
21.3 Defected Chips.....	130
22. Skype interview Jorrit Memel .....	131



## 1. Words List

<b>Arduino</b>	Arduino is very small mini computer based on easy-to-use hardware and software.
<b>Humidity</b>	Humidity is the concentration of water vapour present in air.
<b>Breathability</b>	Air permeability is the ability of a fabric to allow air to pass through it. While air permeable fabrics tend to have relatively high moisture vapor transmission, it is not necessary to be air permeable to be breathable.



## 2. Feedback from tutor

The Smart Solution group of Femke, Isabel, Dimitar and Hoang worked together constantly and detailed on the project from Revit. I met them every week for questions and talking about their group work and progress. In the first quarter they actually did nearly most of the technical part so in the 2<sup>nd</sup> quarter they could really focus on constructing the actual machine Revit was asking for. Their whole group work was very structured and they communicated well with the involved parties. During the midterm presentation they presented their work so far to the company Revit and they were very impressed and happy what the group actually made so far. I saw a lot of mails from Jorrit (Revit) about telling them how happy they are with the results so far and that they should go on with this great work. Furthermore they had some difficulties with one of the group members left earlier because of some circumstances. This group member was responsible for actually making the whole device but he left with no information left for the rest of the group so all of them dove deeper into the mechanical part and constructing part. They managed to make the whole machine by themselves however this wasn't their expertise. They always communicated in a professional and respectful way with the company, with me but also in the group itself. They had some struggles in-between but they always managed to come to solutions with good communication, constantly reflecting with the goal to finish the device and deliver a great result to Revit.



### 3. Feedback from the company: REVIT

#### 3.1 Midterm Feedback

1/18/2020

Mail - Dimitar Rangelov - Outlook

##### RE: Testing test device + fabrics

Jorrit Memel <JMemel@revit.eu>

Fri 12/13/2019 12:15 PM

To: Femke Visser <435542@student.saxion.nl>

Cc: Jenny Hesse <j.hesse@saxon.nl>; Isabel Wesselink <434129@student.saxion.nl>; Le Van Hoang Minh Lê <467475@student.saxion.nl>; Dimitar Rangelov <445392@student.saxion.nl>; Harold Kip <327132@student.saxion.nl>

Dear team members,

So far so good. My feedback short and simple:

- A successful project start with a good introduction. You represented yourself in a friendly, professional matter. It's mandatory that you show interest. Most of you have done that so far.
- There's continuity in the project. It's a good thing that progress is made. As stated from the beginning it is important to come up with a workable and practical solution. In the end you are the start of a development trajectory. I have the feeling that you understand the necessity of the upcoming test device.
- The requirements so far are met. We appreciate that you also helped us out with the additional parameters. Your skill sets are in line with the project and by times exceed the expectations. Keep pushing the limits. It might not be self-evident but we expect nothing less.
- We like your communication skills, your enthusiasm and your drive. Important factors to make sure that a project succeeds. I hope you like the way REVIT! operates as well. Feel free to be open and share your thoughts.
- Developing a testing device is one aspect. We're looking forward to your real life test result and possible findings. Be critical. Share your enthusiasm but also don't be afraid if to express any shortcomings you will find. You're a part of REVIT! during this project. That means that we value your honest opinion.
- One team member is out of sight. So for me it's not clear what your specific input is so far (or what you even look like). Please introduce yourself.

For now, have a nice weekend!

Best regards,

**Jorrit Memel**

Lab Coordinator



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## 3.2 Final Feedback

Jorrit Memel <JMemel@revit.eu>

Thu 1/23/2020 12:15 PM

To: Femke Visser <435542@student.saxion.nl>

Cc: Dimitar Rangelov <445392@student.saxion.nl>; Le Van Hoang Minh Lê <467475@student.saxion.nl>; Isabel Wesselink <434129@student.saxion.nl>

### Communication skills

We are pleased with the way you communicated with us; in a professional and polite manner.

### Problem solving skills

The way you handled unforeseen problems allowed you to broaden your skills but also to find realistic solutions in a timely and professional manner.

### Feedback

We were happy with the open communication and the feedback that was provided. At any given point during the project, we were all on the same page.

### Goals

From our viewpoint, the goals that were set and the parameters that were laid out were met. Great job!

### Teamwork

We are pleased with the way you worked as a team. Each member brought their own background and specific skill set to the table, which allowed the group to thrive.

---

**Jorrit Memel**

Lab Coordinator



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## 4. Feedback from my group members

### From Femke Visser:

During the Smart Solutions Project I have worked with great pleasure with Dimitar. Dimitar always had a lot of input in the meetings and showed with enthusiasm his passion for his study Electronic Engineering by explaining a lot about sensors, software and hardware. He took a lot of initiative during the project by creating different prototypes and he was always open for discussions. Overall, Dimitar is a very motivated and hardworking student who has put a lot of time and effort into the Smart Solutions Semester project.

### From Isabel Wesselink:

It was really nice to work together with Dimitar. He knows a lot about his studies and made sure that every sensor and program is working well. Without him this project would be a flop. He always meets the deadlines and does a great job by making everything work. He gave a lot of innovative ideas, input and is critical about the project. Dimitar works really hard and it was a real pleasure to work with him!

### From Le Van Hoang Minh:

It was a great experience when I worked with Dimitar, he is a really smart guy and knowing what he was doing especially in his major. As a technical guy, I am really respect all the qualities and knowledge that he has and also his own effort in this project. Moreover, his energy and enthusiasm was actually playing an important role to make this project go further. As a friend and also co-worker, it was a real honor to work with him.



## 5. Saxion Festival Smart Solutions Semester

The picture below is representing the email from Saxion Festival Smart Solutions Semester to us the student and in it they are showing their appreciation that we join their festival.

1/18/2020

Mail - Dimitar Rangelov - Outlook

### Open day

Saxion Festival Smart Solutions Semester <[festival.smartsolutions@saxion.nl](mailto:festival.smartsolutions@saxion.nl)>

Thu 1/16/2020 2:27 PM

To: Saxion Smart Solutions Semester <[smartsolutionssemester@saxion.nl](mailto:smartsolutionssemester@saxion.nl)>

Dear students,

Herewith we like to thank you for presenting your project at the Saxion Open Day on behalf of our Smart Solutions Semester. We all found out that not a lot of people were interested; they were all going for specific programs and interdisciplinary working at this stage is probably a bridge too far. The suggestion of some of you to combine the projects with the specific programs in different locations will be investigated. That might be a good idea.

We definitely like to show the people what interesting topics can be done by students when combining different programs.

I was impressed by the diversity of all the projects and what you achieved last half year, on top of that it was great to see how you presented the projects. We have a small gift for you at our project office Z15.1.18 to thank you. Have fun! Good luck finalizing your project.

Kind regards,

**B.H.M. (Erna) Engelen-Fransen**

Projectleider Smart Solutions Semester

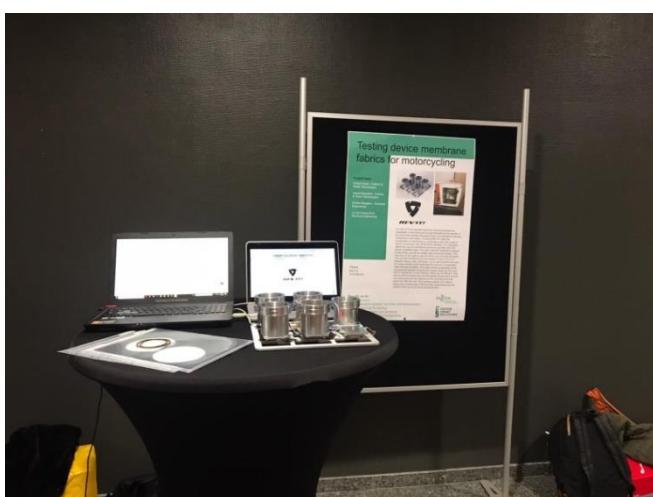
**Saxion | University of Applied Sciences**

Ariënsplein 1 | 7511 JX Enschede | Kamer Z15.1.18

T: +31 (0)6-23453959 | [b.h.m.engelen@saxion.nl](mailto:b.h.m.engelen@saxion.nl)

Werkdagen: maandag, dinsdag, donderdag, vrijdag

The next figure is showing how was looking the table of our team in the Saxion Festival Smart Solutions Semester. There were poster, presentation on one of the computer and demonstration on another computer. Also in front of everything there are final prototype and the textiles from REVIT'.



There is a picture of all the members of the team that joined the Saxion Festival Smart Solutions Semester.



There were some problems on the final prototype after the Saxion Festival Smart Solutions Semester caused from visitors that pushed to much the load cells or damaged some of the sensors. But more details about that and how the problems were solved will be provided in [20. Problem solving](#).



## 6. The assignment

### 6.1 Introduction organization

REV'IT! Sport International designs and develops fashionable riding gear for motorcyclists. We work from our offices in Oss and New York. REV'IT! is a leading brand that produces the highest quality functional riding apparel available in more than 70 countries. Passionate motorcycle riders all over the world are wearing our brand.

### 6.2 Assignment / Project goals



### 6.3 Requirements

- Measuring humidity, temperature and weight of REV'IT cups.
- To have real time access to the data in visible way. Making special software to manage the data and to represent it.
- To have the opportunity to save the data from the experiments.
- The device to be able to work with 6 cups.



## 6.4 What do we expect?

- A research on how these parameters can be analyzed and what the density of sensors should be in order to obtain useful test results.
- To find the relationship between that the humidity and weight of the cups.
- To research the behavior of the textile that was provided by REVI'T.
- A physical and fully functional prototype that includes these electronic construction solutions and operating sensors.

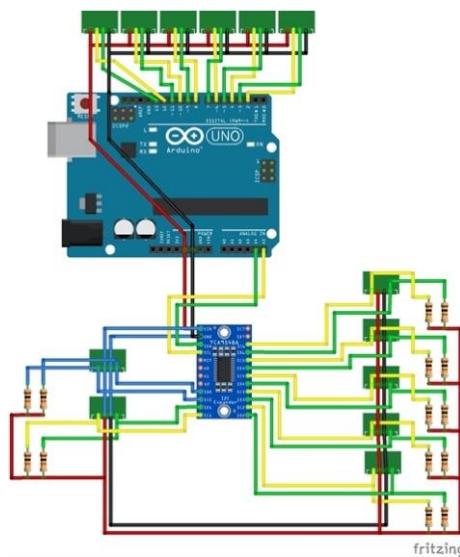


## 7. Final Product

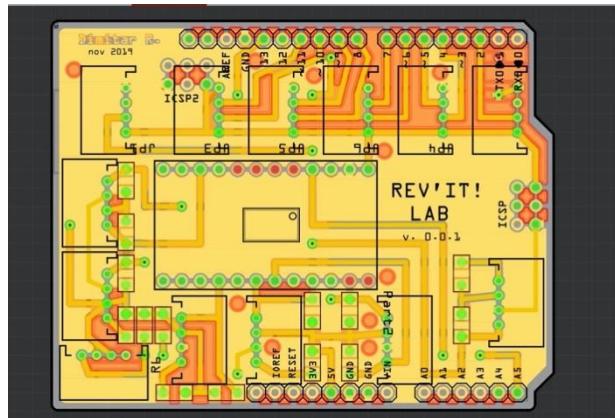
The final product consist from 6 packs of cup, SHT85 (temperature/humidity sensors), 2 x foam rings, 1 x plastic rings and also a metal plate that has on it one motherboard with 6 chips and 6 load cells that are measuring the weight of the cups. Everything is with hotspot connection and really easy changeable.



The figure below is representing a pseudo schematic of the final prototype. The schematic is prepared especially for non-engineering people and is representing all of the components and connection in really easy and accessible way. The top part of it they are six HX711 chips that are connected to 500g load cells bridges. In the bottom of the schematic there are seven SHT85 temperature/humidity sensors. Six of them are for the six cups and one for measuring the environment of the oven. They are connected directly to I2C extender which is connected to the microcontroller.



The figure below is representing the PCB (Printed circuit board) of the final prototype. This is a pseudo representation of it. In real the PCB won't look like that. The PCB is containing only female 4 pin connector for all of the sensors and everything will be really easily to be disconnected or connected. In center there is socket for the I2C extender.



## 8. Assessment rubic

Assessment criterium	How would you grade yourself?	Indicate the evidence provided and explain why this evidence is relevant. *	If the evidence indicated is part of a group project, describe your specific part of the group project here.
<p>1. The student conducts research using a suitable research and design model and substantiates the choice of model and the steps taken.</p>	<p>I think I scored excellent, because at the beginning after the brainstorming I made a technical research about the sensors that we can use in the project. After that I also had interview with a teacher in my field to check if the outcome of my research is reliable. After considering that the outcome of the technical research is sufficient and choosing the right components for the project, I choose to use the rapid prototyping for making the first prototypes, so I could easily and quickly get results and start making experiments to figure out the correlation between humidity and weight in our devices.</p> <p>According to the rapid prototyping it is important that we created a realistic and comprehensive product, rather than doing a lot of research. Because of that based on the first technical research made by me, I build the first prototypes and also the final product. Also because of that we do not have further researches.</p> <p>In the end we had final report contain of the initial research that had be done, mainly described developing process</p>	<p>In the project plan all of the group members contributed something in all of the parts of the document. The project plan is defining the roles and responsibilities and the methodology of the project. Also in it is analyzing the problem that is the main topic of the project. <a href="#">Project Plan(Evidence 1)</a></p> <p>The product manual is really important, because it is part of the rapid prototyping method. It shows in a quick and simple way how the product works and this is really valuable for REV'IT. <a href="#">Product manual(Evidence 11)</a></p> <p>For more detailed information about the process of developing the device and the research that had be done the client can check the final report. The main part of the final report consist of technical research and developing part. In the developing part I am explaining the code of the firmware and the device. Also the hardware components and how they are working.</p> <p><a href="#">Technical Research</a></p>	<p>I worked with Minh and Femke together for the creation of the Product manual. My part is writing the instructions step by step and making the photos of each of the steps.</p> <p>In the project plan all of the group members contributed something in all of the parts of the document.</p> <p>I worked with Minh in the testing one of the sensors in my technical research. My part was making the technical research.</p>



	<p>and most importantly the product manual.</p>	<p><a href="#">(Evidence 2)</a></p> <p><a href="#">Firmware Software</a></p> <p><a href="#">(Evidence 4 )</a></p> <p><a href="#">Device software (Evidence 5.)</a></p> <p><a href="#">Device (Evidence 6)</a></p>	
2. The student collects, analyses, and processes relevant information in a traceable manner.	<p>I think I scored excellent, because I contribute in head developing of the project plan. Also I made technical research and detailed information about the devices in really clean and traceable manner to be easy in the end the client to understand everything. In the process of writing these documents I collected literature about the sensors and innovative solutions.</p> <p>In the end we made the product manual in really understandable and traceable way step by step, so the client to have really client overview how to operate with the device.</p> <p>Also we collect information from our experiments with the device and we analyze the manner of the textiles. And part of the team makes quality reports.</p>	<p>Our team analyzed the behaviour of the textiles from the results from the experiments with the prototypes and the final devices. Beforehand we knew how the textiles supposed to behave in theory but after the experiment we also can represent in graphs this behavior.</p> <p><a href="#">Testing(Evidence 12)</a></p> <p>The project plan is analyzing the problem that is the main topic of the project. I helped in the analyzing the problem and structuring the main research question and the subquestions.</p> <p><a href="#">Project Plan(Evidence 1)</a></p> <p>My part was making the technical research and writing detailed information for the device which is a big part of the content of the final report. The information supposed to be delivered in really clear and traceable manner, so the client without any technical background to understand how the device is working.</p> <p><a href="#">Technical Research (Evidence 2)</a></p> <p><a href="#">Firmware Software</a></p>	<p>I helped in the analyzing of the behavior of the Gortex from the results of experiments with the final device.</p> <p>In the project plan all of the group members contributed something in all of the parts of the document.</p> <p>I worked with Minh and Femke together for the creation of the Product manual. My part is writing the instructions step by step and making the photos of each of the steps.</p>



		<p><a href="#">(Evidence 4 )</a></p> <p><a href="#">Device software (Evidence 5 )</a></p> <p><a href="#">Device (Evidence 6)</a></p> <p>The product manual shows in a quick and structured way how the product works. <a href="#">Product manual(Evidence 11)</a></p>	
3. The student applies knowledge from their own particular discipline and substantiates their choices.	<p>I think I scored excellent, because this project is mainly directed to my specialty and most of the things supposed to be done or supervise by me or my colleague Minh.</p> <p>I make technical research that is involving some much literature and also so many innovative ways of working with the sensors used in the project.</p> <p>I write detailed information about the device and with this information everybody with some technical background can reproduce the prototype really easy.</p> <p>I have so many situations that the product had problems or bugs that I supposed to analyze and fix.</p> <p>Also in other hand I was mainly responsible for the developing of the prototypes and the final product. And I helped in the analyzing of the behavior of the textiles, but this is not related with my specialty.</p>	<p>I have so many situations that the product had problems or bugs that I supposed to analyze and fix. For example at the beginning in the first experiments we did not have satisfying results because the accuracy of the weight sensors was like 140 gram without anything behind the zero. But after some investigating and hard work I made the accuracy to be [140.00] with two signs after that comma. This makes our device and our experiments way more accurate and better.</p> <p><a href="#">Problem Solving (Evidence 13)</a></p> <p>My part was making the technical research and writing detailed information for the device which is a big part of the content of the final report. The information supposed to be delivered in really clear and traceable manner, so the client without any technical background to understand how the device is working.</p>	<p>I worked with Minh in the testing one of the sensors in my technical research. My part was making the technical research.</p>



		<p><a href="#">(Evidence 2)</a></p> <p><a href="#">Firmware Software (Evidence 4 )</a></p> <p><a href="#">Device software (Evidence 5.)</a></p> <p><a href="#">Device (Evidence 6)</a></p> <p>I helped in the analyzing and understanding of the behavior of the textiles.</p> <p><a href="#">Testing (Evidence 12)</a></p>	
4. The student has provided an innovative solution or problem-solving approach for the client.	<p>I think I scored excellent, because the client (REV'IT) is very content and really impressed with the product that we delivered. We started with the assignment they gave us and we succeeded to satisfy all of the requirements and all of the additional supplements that client wanted from us. The product we made is innovative, because there is no similar machine in the world for testing the breathability of textile. Also the sensors for the temperature and humidity SHT85 do not have library to work multiple sensors at once. But I build a brand new library that is able to read the data from multiple sensors at same time with accuracy of 99.7%.</p> <p>In the end the product is not just a prototype or problem-solving approach, it is a real innovate product ready for use from the clients. We do not want to give them just a prototype. We wanted to give them a device that directly will be implemented in their labs and their verification</p>	<p>The assignment shows the problem REV'IT had and the expectations they had. <a href="#">The assignment</a></p> <p>The feedback we got from REV'IT is important, because it shows that the client is impressed by the end result we made and that we provided a product that can be directly implemented in their labs. <a href="#">Feedback from the company: REV'IT</a></p> <p>The technical research and more detailed description of the device and the software is giving the big picture how inovative is the product that our team build. And how many innovative solution we implement in the project as implementing way how multiple SHT85 sensors to work at same time.</p> <p><a href="#">Technical Reseach (Evidence 2)</a></p> <p><a href="#">Device (Evidence 6)</a></p> <p><a href="#">Testing (Evidence 12)</a></p> <p>Because of the</p>	<p>I had the help of my team to solve some of the problems that pop up in the developing process, as laser cutting and drilling holes.</p> 

	<p>process.</p>	<p>circumstances that one of our team members (Harold Kip) supposed to leave our team, we should finish his part of the work. He was responsible for the mechanical part of the project. Anything related with his speciality. Because of his missing we supposed to laser cut the foam and plastic rings for the cups. Also to drill wholes on the metal cups.</p> <p><a href="#"><u>Drilling (Evidence 3)</u></a></p> <p><a href="#"><u>Laser (Evidence 7)</u></a></p> <p>Also there were some problems that I supposed to solve. For examples after <a href="#"><u>Smart Solution festival</u></a> there were burned sensors and defected board that I supposed to analyze the problem and fix everything on the device.</p> <p><a href="#"><u>Problem Solving (Evidence 13)</u></a></p>	
5. The student communicates in a respectful, purposeful, and professional manner with all internal and external stakeholders.	<p>I think I scored sufficient, because I have to make interview with teachers in my field and a group interview with Jorrit Memel from REV'IT. Also I have to communicate with the tutor and the other group members via mail and I communicated in a professional manner.</p> <p>Also the client Jorrit Memel, the member of REV'IT, my tutor Jenny Hesse and my group member were content about the professional</p>	<p>In the feedback of the client, my tutor and my group members one is able to read that the communication during the project was considered professional and pleasant with me.</p> <p><a href="#"><u>Feedback from the client: REV'IT (Jorrit Memel)</u></a></p> <p><a href="#"><u>Feedback from the tutor: Jenny Hesse</u></a></p> <p><a href="#"><u>Feedback from my group members</u></a></p> <p>Also as a group we supposed to make interview</p>	<p>During the project I was the electrical and electronics engineer and as such I supposed to make interview with a teacher in my field for the purpose of research.</p>

	<p>communication.</p>	<p>with our clients and try to keep the professional manner of communication.</p> <p><a href="#">Interview with REVI'T (Evidence 14)</a></p> <p>Also we had midterm and final presentation.</p> <p><a href="#">Midterm presentation (Evidence 9)</a></p> <p><a href="#">Final Presentation (Evidence 10)</a></p> <p>I made an interview via email with Umit Guler in really direct and professional way.</p> <p><a href="#">Interview with Umit Guler (Evidence 8)</a></p>	
6. The student takes responsibility within the group for the solutions and partial solutions as well as the processes.	<p>I think I scored excellent, because my part in the project is to build the first prototypes and the final product. This means that I supposed to satisfy all of the main requirements of the client and also to add all of the additional supplements that REVI'T wanted.</p> <p>Also to provide a technical research and detailed information about the developing process of this innovative product. I should write down all of the innovative solutions and I implement in the device.</p> <p>Making the content of the product manual was also my responsibility.</p> <p>Also my responsibility was to solve all of technical problem related with the device and to help my team with the mechanical work left from our</p>	<p>My part was making prototypes, final product, and technical research and writing detailed information for the device which is a big part of the content of the final report. The information supposed to be delivered in really clear and traceable manner, so the client without any technical background to understand how the device is working.</p> <p><a href="#">Technical Research (Evidence 2)</a></p> <p><a href="#">Firmware Software (Evidence 4 )</a></p> <p><a href="#">Device software (Evidence 5.)</a></p> <p><a href="#">Device (Evidence 6)</a></p> <p>Because of the circumstances that one of our team members (Harold Kip) supposed to leave our team, we should finish his</p>	<p>I had the help of my team to solve some of the problems as laser cutting and drilling holes.</p> <p>I worked with Minh and Femke together for the creation of the Product manual. My part is writing the instructions step by step and making the photos of each of the steps.</p> 

	<p>ex-member.</p>	<p>part of the work. He was responsible for the mechanical part of the project. Anything related with his speciality. Because of his missing we supposed to laser cut the foam and plastic rings for the cups. I take the responsibility and make the holes in the cups by my own.</p> <p><a href="#">Drilling (Evidence 3)</a></p> <p><a href="#">Laser (Evidence 7)</a></p> <p>I write all of the content in the product manual and also I make all of the pictures step by step in it. The product manual shows in a quick and structured way how the product works.</p> <p><a href="#">Product manual (Evidence 11)</a></p>	
7. The student describes how they have looked at the project/question from the perspective of another discipline and what this means for the choices that were made.	<p>I think I scored sufficiently, because I am always trying to discuss the solutions that I am doing with other specialties. I am trying to put their ideas in the real product.</p> <p>Also I helped my team in the analyzing of the behavior of the textiles from the results of experiments with the final device. I tried also to learn new thing from another discipline.</p>	<p>I helped in the analyzing of the behavior of the Gortex from the results of experiments with the final device.</p> <p><a href="#">Testing (Evidence 12)</a></p> <p>I am trying to put their ideas in the real product.</p> <p><a href="#">Firmware Software (Evidence 4)</a></p> <p><a href="#">Device software (Evidence 5)</a></p> <p><a href="#">Device (Evidence 6)</a></p>	<p>I gave electrical engineering ideas for analyzing of the textile. And we as team discuss different ideas from the different disciplines.</p> <p>Together with the whole group we discussed this and made the decision.</p>
8. The student reflects on their actions and adjusts these actions based on this reflection.	<p>I think I scored excellent, because I am always accepting feedback for my work or behavior. I adjusted the project plan and the final report after the feedback.</p> <p>Also after the first experiment we did not have satisfying</p>	<p>At the beginning in the first experiments we did not have satisfying results because the accuracy of the weight sensors was like 140 gram without anything behind the zero. But after some investigating and hard</p>	<p>Every time when REVIT wanted new thing to be add it in the prototype or in the final product I was implementing it.</p> 

result and I adjusted the prototype to start to be more accurate and to have better and accurate results in the future. I am accepting also feedback about the prototypes and final device and I always doing my best to make the feedback in reality.

work I made the accuracy to be [140.00] with two signs after that comma. This makes our device and our experiments way more accurate and better.

[Problem Solving \(Evidence 13\)](#)

\* ) Please add pieces of evidence (or a reference) to this document



## 9. Project Plan

# Project Plan - Smart Solutions Semester

REV'IT!

L.26195 Testing device membrane fabrics for motorcycling



**REV'IT!**

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Project Plan -  
Smart Solutions Semester  
REV'IT!  
L.26195 Testing device membrane fabrics for motorcycling

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## Table of Contents

<b>List of Tables</b>	<b>iv</b>
<i>Tables</i>	iv
<b>Preface</b>	<b>v</b>
<b>1     Introduction</b>	<b>1</b>
1.1 <i>Problem analysis</i>	2
1.2 <i>Research objectives</i>	2
1.3 <i>Research question and sub questions</i>	4
<b>2     Methods</b>	<b>5</b>
2.1 <i>Literature research</i>	5
2.2 <i>Interviews</i>	5
2.3 <i>Measurement</i>	5
2.4 <i>Simulation</i>	5
<b>3     Role &amp; Responsibility</b>	<b>6</b>
<b>4     Planning</b>	<b>8</b>
<b>5     Budget</b>	<b>12</b>
<b>6     Risk analysis</b>	<b>13</b>
<b>Bibliography</b>	<b>15</b>
<b>Appendices</b>	<b>1</b>



## List of Tables

**Tables**

Table 1	6
Table 2	8
Table 3	12
Table 4	12
Table 5	13
Table 6	14



## Preface

This research report for REV'IT! is commissioned by Saxion University of Applied Science as part of the Smart Solutions Semester. The following study fields are involved; Electrical Engineering, Mechanical Engineering and Fashion and Textile Technologies.

The goal of this research is to provide REV'IT! a breathability testing device for membrane fabrics for motorcycling garments. The purpose of this report is to implement our knowledge and to combine the knowledge of each team member to fulfill the requirements of the company.

The group exists of five team members from different specializations: Harold Kip (MT), Le Van Hoang Minh (EIE), Dimitar Rangelov (EIE), Femke Visser (FFT) and Isabel Wesselink (FFT).

September 12, 2019

Enschede

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## 1 Introduction

REV'IT! is a Dutch company, based in Oss, which develops innovative motorcycle clothing since 1995. REV'IT! is a worldwide known company with over a thousand dealers all over the world. After five years REV'IT! introduced the 'Engineered skin design' concept, a new method for product development. A groundbreaking method to deliver higher protective motorcycling products. In 2009 REV'IT! made a license agreement with Gore-Tex. By combining Gore-Tex with the Engineered skin, the performance and safety of the products have improved (REV'IT!, 2019).

REV'IT! makes motorcycle clothing for men and women from 18 years and older. The company creates collections which are divided in three different types of motorcycle garment categories: Sport, Adventure and Urban. These categories are based on the level of performance of the motorcyclist. REV'IT! also provides a lifestyle collection for both men and women.

With the lab located in Oss, REV'IT! tests their own fabrics at their own headquarters. Before the garments are produced the fabrics will first be tested in the lab. The fabrics are tested on their safety level to see if the products fulfill to the standards. Another important factor is to test the materials on the comfort level. REV'IT! aim is to provide protective and comfortable products towards their customers. A few examples of these tests are the tensile strength test, abrasion resistance, dimensional stability and many more. While performing these tests the seam strength, the stretch ability and the wear resistance of the products are for example tested (REV'IT!, 2019).

All information is acknowledged on the 5th of September 2019 by Mr. Memel, the Lab Coordinator at REV'IT! Oss.



## 1.1 Problem analysis

REV'IT! currently has a laboratory in Oss to test the materials. This lab was originally built to test the safety features of their motorcycling garments. By doing that REV'IT! was able to see if a suit would pass the European Union mandatory test for motorcycling garments. REV'IT! want to take this a step further. They reckon a driver who is comfortable is safer because they are not distracted by, for instance, the warmth of the suit or the humidity. It is therefore important to test the breathability of the fabrics. REV'IT! currently tests the breathability of membranes in combination with different types of fabrics according to the ASTM 96-95 standard. The standard defines the use of a predefined aluminum cup filled with 100 grams of distilled water. The fabric is placed on top of the cup with an airtight seal around the corners, so the only way for the water to get out of the cup is through the fabric. The whole setup of the cup and fabric is placed in an oven of 32 to 37 degrees Celsius, depending on the type of experiments. After 120 hours, the cup is removed from the oven for measurements which evaluates the amount of evaporated water through the fabric. This value will be extrapolated to the international standard of grams per square meter per 24 hours (Huang & Qian, 2008).

REV'IT! is defining the current testing procedure as not efficient and would like to change it. They are not able to monitor the cup and testing environment as their only data points at the moment are the weighting of the cups before and after the test. The testing device does not have sensors which could collect data as temperature, humidity, weight of the cups at all times during the test. However, one of the most important things is to be able to monitor and test the behavior of the fabrics in combination with the membranes for breathability in different phases of the test. For example, the well-known Gore-Tex fabric requires a certain amount of time to start functioning in full capability. It is important to know when fabrics in combination with a membrane becomes breathable. This variable is of great importance for

REV'IT! as they offer biker wear for different kinds of motorcyclist, each with different requirements. Furthermore, these values and information will result in a more efficient match of fabrics with membranes for the type of bike activities (Sport, Adventure and Urban). Each activity has its own requirements for motorcycling garments as intensity and duration of the drive differs between them.

## 1.2 Research objectives

The most important factor for designing a motorcycling suit is protection, but the suit must also protect the rider from weather conditions such as rain, sun or wind. Ventilation is therefore key. In summer the suit can overheat the motorcyclists' body. Therefore, the appropriate protection should not disturb the thermal balance. The vapor permeability of the motorcycling garments must be high so the sweat can be evaporated. Motorcycling clothing is mainly made out of leather or textile materials, for instance nylon, polyester, polyamide etc. Suits made out of leather is more durable but makes it impossible for the human body to breathe. The clothing made out of textile currently provide protection against weather conditions while the perspiration will get through. Different fabric compositions are required for each type of motorcyclist. The fabrics for the garments are combined with membranes so it feels comfortable on the skin (de Rome, 2019) (Zwolinska, 2013).

The most commonly used membrane is from GORE-TEX. The GORE-TEX membrane is a thin stretched layer of polytetrafluoroethylene (ePTFE). ePTFE is also known as Teflon. The membrane is attached to an outer fabric and the lining. GORE-TEX prevents water from penetrating the product and allows evaporation of sweat, which is known as the wicking-effect. Because of the membranes the products become windproof, waterproof and breathable. Gore-Tex provides the wearer a thermal protection, reduces heat and allows the wearer to move.



The membrane that GORE-TEX uses is only 0,01 mm thick and has about 1,4 billion pores. These pores are twenty thousand times smaller than a raindrop and seven hundred times bigger than a water vapor molecule. Because of this, the membrane is fully waterproof, but the perspiration will get through. GORE-TEX's membrane is also windproof because it has a structure of a hedge. You can only see this under a microscope (Anitlope Outdoor, 2019). (Ismal & Paul, 2018).

Another company that makes membranes is eVent. eVent is also one of the most and biggest known alternatives for the GORE-TEX membrane. The eVent membrane is made out of the same materials as GORE-TEX. But the membrane of eVent uses a dry system. This makes it possible to get the moisture out in an instant. This is also called DirectVenting, a design of the brand itself (Norway Geographical, 2019).

In combination with the membranes, the breathability of the membranes depends on the fabric its laminated to. It is important to know which combination of fabric and membrane is breathable, to make the best usable motorcycling suit. Therefore, it is important to measure the temperature, humidity, evaporation time and weight of the fabrics (Zwolińska, 2013).

While the water evaporates in the oven, humidity will develop. Inside the oven there will be an absolute humidity. Absolute humidity is the mass of water vapor divided by the mass of dry air in an amount of air at a given temperature. This means, when the air gets hotter the more water the air can contain (Chandler, 2019).

The fabrics used within the products must meet certain quality standards. One of these standards is the ISO standard. The American version of this standard is the ASTM standard. REV'IT! is currently using for permeability the ASTM 96-95 standard. REV'IT! has developed a permeability device according to the ASTM 95-96 standard. The aim is to determine when the fabrics breathe during the whole test, but this is not achieved with the current test. Therefore, the aim of the research is to create a testing device for REV'IT! which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity. These measurements are taken throughout the test and displayed in a graph. With this data REV'IT! can determine how long it takes for a fabric to breathe. The device will be a REV'IT! standard and therefore the ISO and ASTM standard does not need to be followed exactly.



### 1.3 Research question and sub questions

To address the problem, as described in 1.1 Problem Statement, the following main and sub-questions have been composed.

#### Main question

To what extent can a test device be developed to get a better understanding of the breathability of fabrics?

#### Sub-questions

Sub question 1: What kind of equipment is required to measure the weight of the cups at all times?

Sub question 2: What kind of equipment is required to measure the temperature inside the oven at all times?

Sub question 3: What kind of equipment is required to measure the humidity inside the oven at all times?

Sub question 4: How does the outside humidity affect the breathability of fabrics?

#### Preconditions and project deliverables

The smart solutions semester project is completed successfully when a testing device is developed which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity in the oven and can display these measurements in a graph for REVIT!



## 2 Methods

This chapter describes the methods used within the research for REV'IT!

This research is a combination of quantitative and qualitative types of research. Qualitative Research is primarily exploratory research. It is used to gain an understanding of underlying reasons, opinions, and motivations. It provides insights into the problem or helps to develop ideas or hypotheses for potential quantitative research. Quantitative Research is used to quantify the problem by way of generating numerical data or data that can be transformed.

### 2.1 Literature research

A qualitative literature research has been carried out to answer all sub questions to obtain general information about the subjects. A lot of information will be gathered from international standards as they form the basis for the current testing procedure and include a lot of in-depth information on the why and how.

### 2.2 Interviews

Semi-structured interviews will be conducted to answers sub questions. Interview schemes will be made before the interviews and there will be possibilities for extra questions during the interviews. As Jorrit Memel is the sole person in charge of the testing at REV'IT! he is the only person available to interview to gather more information about the current testing device and the requirements for the new testing device. Therefore, the population and the sample of the interview is one. The interviewee will be approached for the interview by email and the interview will be held at Saxion Enschede via Skype.

To make the testing device additional help and information is needed from different experts. Therefore, to gather more information about the use of the sensors and the electronics parts for the testing device the Hardware Lab/Electronics teacher at Saxion University of Applied Science, Umit Guler will be interviewed.

To collect more information about the equipment which can measure the weight of the cups and the construction of the cup the employee Mechanical Systems/High Precision Fabrication at Van der Beek's Beheer B.V. Romar Willems will be interviewed. The population and the sample of the interviews with the experts are two. The interviewee will be approached for the interviews by email and the interviews will be held at Saxion Enschede and at Van der Beek's Beheer B.V.

### 2.3 Measurement

Measurement will be made to test and evaluate the behavior and characteristics of fabrics and membranes. These measurements will be carried out in the chemical laboratory at the Epy Drost building of Saxion Enschede. There are already premade measurements by Jorrit Memel in the lab at REV'IT! that will be used in the research as reference. However, also the research will contain technical measurements based on the performance and accuracy of the device. This will help to develop a device which is more efficient.

Once the testing device for REV'IT! is developed various membranes in combination with the fabrics provided by REV'IT! will be tested on their breathability.

### 2.4 Simulation

Simulations will be used to test and evaluate the behavior and characteristics of fabrics and membranes. Also, to try to predict the ratio of the humidity inside and outside of the cups. However, the simulation will be used mainly in the developing process of the hardware and the software. On the other hand, the simulations will also help to track how the real device will behave and perform in a real environment before its even developed. Later on, this will be beneficial for the accuracy and speed of the product.



### 3 Role & Responsibility

Every person who is part of this project has a specific role and responsibility which corresponds to his or her specialty and interests. In this way everyone can use their full potential, and this will affect the end result.

See table 1 for the roles and responsibilities for everybody within the group.

**Table 1**  
**Roles & Responsibilities**

<i>Role</i>	<i>Identity</i>	<i>Responsibilities</i>
Chairman and Quality Manager	Femke Visser	Establishing a connection with the client and playing a role as contact person. Testing and evaluating the behavior and characteristics of fabrics and membranes. Also writing detailed quality reports.
Quality Manager	Isabel Wesselink	Testing and evaluating the behavior and characteristics of fabrics and membranes. Also writing detailed quality reports
Mechatronic Engineer	Harold Kip	Testing and developing the mechanical system of the device. Also forming mechanical electronics of the sensors in the final product. Testing and evaluating the behavior and characteristics of fabrics and membranes.
Embedded Engineer and Software Developer	Dimitar Rangelov	Developing hardware and embedded software meeting the criteria and characteristic of the project. Also adapting or creating a firmware for representing the data of the tests. Testing and evaluating the behavior and characteristics of fabrics and membranes.
Embedded Engineer	Le Van Hoang Minh	Developing hardware and embedded software meeting the criteria and characteristic of the project. Testing and evaluating the behavior and characteristics of fabrics and membranes.



## 4 Planning

See table 2 for the planning for all weeks during the project including facilities (working place (e.g. working space)).

**Table 2  
Planning**

Week	Outcome	Responsible	Facilities	Time (Hours)
1.1	- First group meeting	All	Saxion Enschede	24
	- Kick-Off Smart Solutions Semester	All	Saxion Enschede	
	- Research on REV'IT!	All	Home office	
	- Meeting with REV'IT!	All	REV'IT! Oss	
1.2	- Group meeting: Monday, Tuesday, Wednesday and Thursday	All	Saxion Enschede	32
	- Friday: Remotely working	All	Home office	
	- Meeting with Jenny (tutor)	All	OTSWO 3rd Floor - Epy Drost	
	- Researching ISO and MVTR standards.	Harold, Femke & Isabel	Saxion Enschede	
	- Research different sensors for the device	Dimitar, Harold & Minh Lê	Saxion Enschede, home office	
	- Work on project plan	All	Saxion Enschede, home office	
	- Send Project Plan to Jorrit and Jenny	Femke	Saxion Enschede	
	- Request cup, membrane, fabrics and standards	Femke	Saxion Enschede	
	- Develop a firmware	Dimitar	Home office	
1.3	- Group meeting: Monday, Tuesday, Wednesday and Thursday	All	Saxion Enschede	32
	- Friday: Remotely working	All	Home office	
	- Meeting with Jenny (tutor)	All	OTSWO 3rd Floor - Epy Drost	
	- Brainstorm for ideas testing device	All	Saxion Enschede	
	- Interview with Jorrit Memel about the project plan	All	Saxion Enschede, Skype	
	- Literature research of the provided standards by Jorrit	Harold, Femke & Isabel	Saxion Enschede	
	- Send final project plan to Jenny and Jorrit	Femke	Saxion Enschede	
	- Personal Deadline 20/09/2019: Project Plan	All	Saxion Enschede, home office	
	- Deadline 22/09/2019: Final Project Plan	All	Saxion Enschede, home office	
	- Group meeting: Monday, Tuesday, Wednesday and			



1.4	<p>Thursday</p> <ul style="list-style-type: none"> <li>- Friday: Remotely working</li> <li>- Meeting with Jenny (tutor)</li> <li>- Receive cup, fabric samples, membrane and standards from Jorrit</li> <li>- Create a technical drawing of the cup</li> <li>- Remake the original cup for testing</li> <li>- Research: Received standards of the test by Jorrit</li> <li>- Research: How to attach the sensors to the cup</li> <li>- Test the compositions of the received fabrics</li> <li>- Update Jorrit about project progress</li> </ul>	All	Saxion Enschede	32
		All	Home office OTSWO 3rd Floor - Epy Drost	
		All		
		Harold	Saxion Enschede	
		Harold	Van der Beek's Beheer B.V.	
		Femke, Isabel	Saxion Enschede	
		Dimitar, Minh Lê	Saxion Enschede, home office	
		Femke, Isabel	Chemical lab - Epy Drost	
		Femke	Saxion Enschede	
1.5	<p>- Group meeting: Monday, Tuesday, Wednesday and Thursday</p> <ul style="list-style-type: none"> <li>- Friday: Remotely working</li> <li>- Meeting with Jenny (tutor)</li> <li>- Test: How does the original cup relate to the remake cup</li> <li>- Test: The behavior of the sensors with the cup</li> </ul>	All	Saxion Enschede	32
		All	Home office	
		All	OTSWO 3rd Floor - Epy Drost	
		Harold	Chemical lab	
		Dimitar, Minh Lê	Hardware lab - Wolvecamp	
1.6	<p>- Group meeting: Monday, Tuesday, Wednesday and Thursday</p> <ul style="list-style-type: none"> <li>- Friday: Remotely working</li> <li>- Meeting with Jenny (tutor)</li> <li>- Research: Choose the best option sensor for the cup</li> <li>- Start prototyping</li> <li>- Update Jorrit about project progress</li> </ul>	All	Saxion Enschede	32
		All	Home office	
		All	OTSWO 3rd Floor - Epy Drost	
		Dimitar, Minh Lê	Saxion Enschede	
		All	Hardware lab - Wolvecamp	
		Femke	Saxion Enschede	
1.7	<p>- Group meeting: Monday, Tuesday, Wednesday and Thursday</p> <ul style="list-style-type: none"> <li>- Friday: Remotely working</li> <li>- Meeting with Jenny (tutor)</li> <li>- Prototyping</li> <li>- Personal deadline 20/10/2019: finish prototype</li> <li>- Deadline 20/10/2019: First version personal portfolio</li> </ul>	All	Saxion Enschede	32
		All	Home office	
		All	OTSWO 3rd Floor - Epy Drost	
		All	Hardware lab – Wolvecamp	
		All	Saxion Enschede, home office	
		All	Saxion Enschede, home office	
1.8	<p>- Group meeting: Monday, Tuesday, Wednesday and Thursday</p> <ul style="list-style-type: none"> <li>- Friday: Remotely working</li> </ul>	All	Saxion Enschede	32
		All	Home office	



	- Meeting with Jenny (tutor) - Test prototype - Test different types of fabrics with prototype - Start quality report - Update Jorrit about project progress	All All Femke, Isabel Femke, Isabel Femke	OTSWO 3rd Floor - Epy Drost Hardware lab - Wolvecamp Chemical lab - Epy Drost  Saxion Enschede Saxion Enschede	
1.9	- Group meeting: Monday, Tuesday, Wednesday and Thursday  - Friday: Remotely working - Meeting with Jenny (tutor) - Quality report - Buffer week	All All Femke, Isabel	Saxion Enschede  Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
1.10	- Group meeting: Monday, Tuesday, Wednesday and Thursday  - Friday: Remotely working - Meeting with Jenny (tutor) - Analyze breathability testing results of the fabrics (120 hours test) - Update Jorrit about project progress - Personal deadline 17/11/2019: finish quality report	All All Femke, Isabel Femke All	Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede  Saxion Enschede  Saxion Enschede, home office	32
2.1	- Group meeting: Monday, Tuesday, Wednesday and Thursday  - Friday: Remotely working - Meeting with Jenny (tutor) - Analyze breathability testing results of the fabrics (120 hours test)	All All Femke, Isabel	Saxion Enschede  Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.2	- Group meeting: Monday, Tuesday, Wednesday and Thursday  - Friday: Remotely working - Meeting with Jenny (tutor) - Update Jorrit about project progress	All All Femke	Saxion Enschede  Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.3	- Group meeting: Monday, Tuesday, Wednesday and Thursday  - Friday: Remotely working - Meeting with Jenny (tutor) - Deadline 08/12/2019: Second version personal portfolio	All All All	Saxion Enschede  Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede, home office	32
2.4	- Group meeting: Monday,	All	Saxion Enschede	32



	Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Update Jorrit about project progress	All All Femke	Home office OTSWO 3rd Floor - Epy Drost	
2.5	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Preparations presentation Smart Solutions Festival	All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.6	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Finalize presentation Smart Solutions Festival	All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.7	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Deadline 17/01/2020: Smart Solutions Festival	All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede, home office	32
2.8	- Deadline 26/01/2020: Final version personal portfolio - Deadline 26/01/2020: Final group products	All All	Saxion Enschede, home office Saxion Enschede, home office	



## 5 Budget

To find the best solution a few prototypes need to be built, this so different tests can be run to see the effect of different sensors, the placement of the sensors and the ability to modify the cups for sensor usage. See table 3 and 4 for the budget which is needed for building the prototype. All products above are without VAT and shipping + handling

**Table 3**  
*Electronic devices budget*

<i>Electronic device</i>	<i>Amount</i>	<i>Costs per piece</i>	<i>Source</i>
SHT85 Humidity, Temperature Sensor	1	€25	Mouser
ADA 2857 Humidity, Temperature Sensor	1	€15	Mouser
FlexiForce A301 Sensor 1lb	1	€15	Anratek
MINI LOAD CELL - 500G, STRAIGHT	1	€10	Anratek
LOAD CELL AMPLIFIER - HX711	2	€10	Anratek
Controller	1	€20	Anratek

**Table 4**  
*Mechanical devices budget*

<i>Mechanical device</i>	<i>Amount</i>	<i>Costs per piece</i>	<i>Source</i>
Cups	2	€150	Solidworks Cost Analisys
Oven Memmert UN30	1	€1000	Dijkstra Vereenigde



## 6 Risk analysis

To address the risks that can impact the research during the project a table has been made on how to manage the risks. See table 3 for the risk analysis and table 4 for the comparation of the maximum score and the actual score.

**Table 5**  
*Risk Analysis*

Category	Risk	Value*	Risk Chance	Risk Impact	Risk Tot
<b>Time factor</b>					
1	Estimated duration of the project	2 quarters	1	4	4
2	Does the project have a deadline?	Yes	0	4	0
3	Does the project team have enough time to finish the project?	Yes	2	5	0
<b>Complexity of the project</b>					
4	Is it an adjustment or a new project?		New project	2	2
5	Are there other projects dependent on this project?		No	0	5
6	Is the project divided by parts? And is the Project dependent on the connection between them?		Yes	3	4
<b>The project group</b>					
7	Who are the project members?		Students	3	4
8	Will the project members feel responsible for the result?		Yes	1	5
9	Can the project members help each other?		Yes	0	5
10	Are there any users of the end result in the project group?		Yes	0	3
<b>The Scrum master</b>					
11	Have the Scrum master any experience being scrum		No	2	2
12	Does the Scrum master feel responsible for the result?		Yes	1	5
13	Can the Scrum master help the project members with starting to work?		Yes	2	4
<b>The tools</b>					
14	Can the hardware crash?		Yes	4	5
15	Can we lose all code when lap top crashes?		No	0	5
16	Do we have backup hardware?		No	1	5
17	Does every project member have experience with hardware		No	3	4
18	Does every project member have experience with the programing languages?		No	3	4
					Total Points 113
					Total risk percentage** %

\*Value chosen by leader

\*\*Total risk percentage is the total amount of points divided by 450 (max score) multiplied by 100



**Table 6**  
*Maximum score vs actual score*

<i>Category (with maximum score vs actual score)</i>	<i>Maximum</i>	<i>Score</i>
Time factor	75	14
Complexity of the project	75	16
The project group	100	17
The Scrum master	75	17
The tools	125	49



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## 10. Technical Research

I fully write by my own the next document. The purpose of this it is to represent the technical research that has been done for the project.

SAXION UNIVERSITY OF APPLIED SCIENCES

# Technical Research

Smart Solutions Semester 1  
2019-2020

*Author: Dimitar Rangelov*

*Version: 0.0.1*



## Contents

Introduction.....	2
1. Temperature and Humidity Sensor .....	3
1.1 Simulations on Humidity domain .....	3
1.2 Simulations on Temperature domain.....	4
1.3 Results for Humidity .....	5
1.4 Results for Temperature .....	6
1.5 Function Simultaneously of Temperature and Humidity.....	7
1.6 Hysteresis .....	7
1.7. Response speed.....	8
1.8 Testing and evaluating .....	8
2. Weight Sensor .....	10
2.1 Load Cell Basics.....	10
2.1.1 Hydraulic Load Cells.....	10
2.1.2 Pneumatic Load Cells.....	11
2.1.3 Strain Gauge Load Cells.....	11
2.2 Testing and evaluating .....	12
2.2.1 Reference research.....	12
2.2.2 Applying the reference research .....	13
3. Micro controllers .....	15
3.1 Arduino UNO .....	15
3.2 Arduino NANO.....	16
3.3 Arduino DUE .....	16
3.4 Arduino MEGA 2560 .....	17
3.5 Comparison .....	17
4. Architecture.....	18
5. Graphical user interface .....	19
6. Bibliography.....	20



## Introduction

REV'IT! is a Dutch company, based in Oss, which develops innovative motorcycle clothing since 1995. REV'IT! is a worldwide known company with over a thousand dealers all over the world. After five years REV'IT! introduced the 'Engineered skin design' concept, a new method for product development. A groundbreaking method to deliver higher protective motorcycling products. In 2009 REV'IT! made a license agreement with Gore-Tex. By combining Gore-Tex with the Engineered skin, the performance and safety of the products have improved (REVIT!, 2019).

REV'IT! makes motorcycle clothing for men and women from 18 years and older. The company creates collections which are divided in three different types of motorcycle garment categories: Sport, Adventure and Urban. These categories are based on the level of performance of the motorcyclist. REV'IT! also provides a lifestyle collection for both men and women.

With the lab located in Oss, REV'IT! tests their own fabrics at their own headquarters. Before the garments are produced the fabrics will first be tested in the lab. The fabrics are tested on their safety level to see if the products fulfill to the standards. Another important factor is to test the materials on the comfort level. REV'IT! aim is to provide protective and comfortable products towards their customers. A few examples of these tests are the tensile strength test, abrasion resistance, dimensional stability and many more. While performing these tests the seam strength, the stretch ability and the wear resistance of the products are for example tested (REVIT!, 2019).

All information is acknowledged on the 5th of September 2019 by Mr. Memel, the Lab Coordinator at REV'IT! Oss



## 1. Temperature and Humidity Sensor

The aim of this chapter is to define which sensor is most suitable for the research project. This has been done to up efficiency and the accuracy of the device that will be built.

The sensors are divided on different classes and the priority of this research is mainly sensors that are high class and also has high specification. Because of that the DHT11 and overall the DHT family are clearly a different class of sensor with substantially lower specification and has been dropped from further investigation. In previous tests it performed perfectly well with respect to its specification.

The sensors are mainly from several families and manufactorys but with almost same specifications and class. Furthermore will be simulated the eventual behavior in humidity domain and temperature domain separately. After that will be shown the results and the Function Simultaneously of Temperature and Humidity that will represent clearly in 3d the relationship between temperature and humidity and how this affects the sensor by its own.

### 1.1 Simulations on Humidity domain

In the pictures below are representing the results of the simulation for humidity of each of the sensors. In the first graph is visible that as big is the graph as less accurate and more percent difference has the sensor. And other way around as small is the graph as more accurate is the sensor.

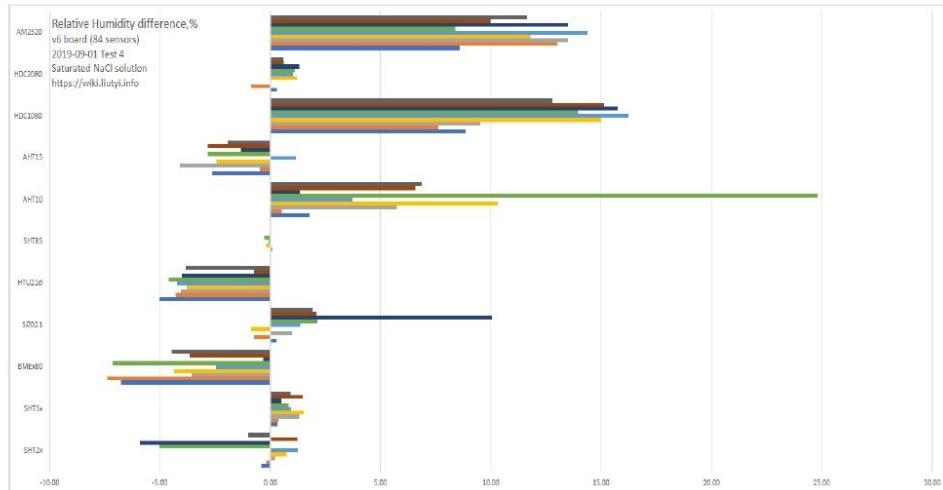


Figure 1 Relative Humidity difference [1]



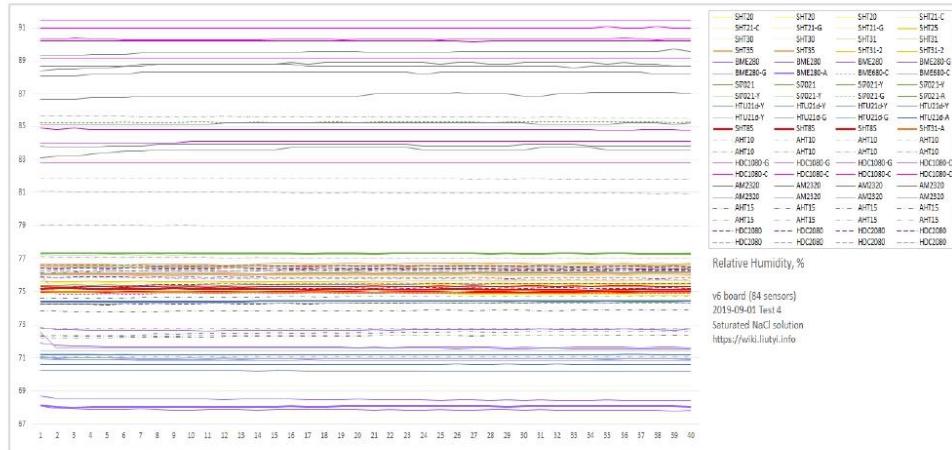


Figure 2 Relative Humidity Sensor [1]

## 1.2 Simulations on Temperature domain

In the pictures below are representing the results of the simulation for temperature of each of the sensors. In the first graph is visible that as big is the graph as less accurate and more percent difference has the sensor. And other way around as small is the graph as more accurate is the sensor.

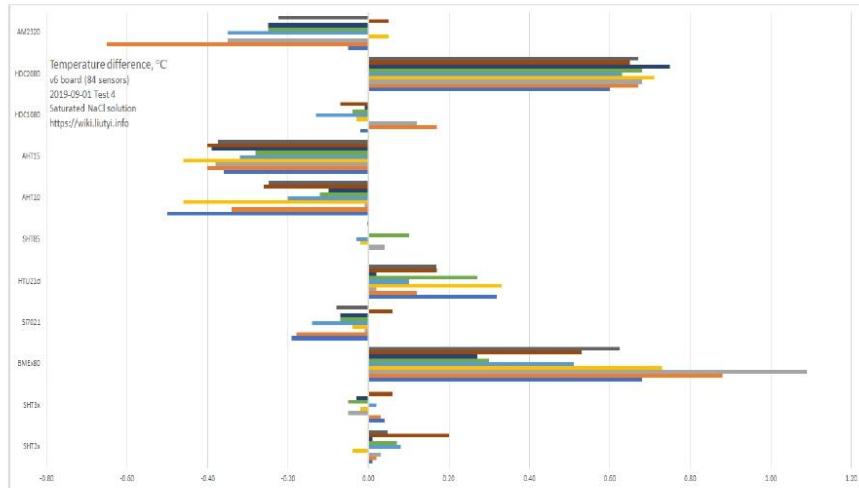
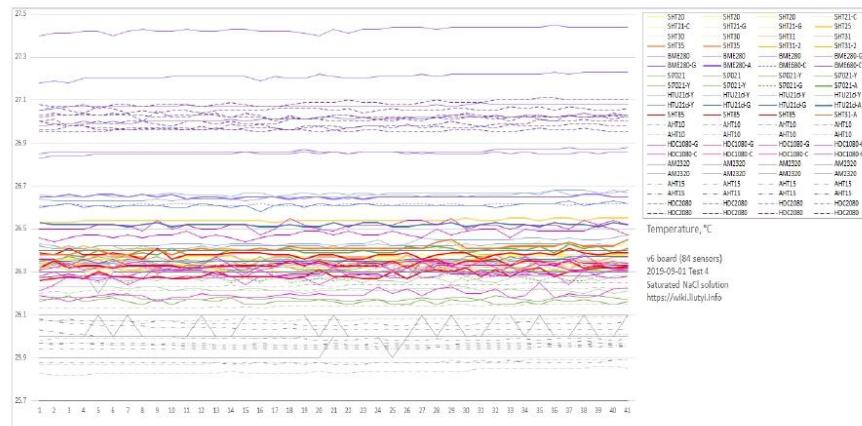


Figure 3 Temperature difference [1]





**Figure 4** Temperature measurements [1]

### 1.3 Results for Humidity

The plot below showing the deviation of humidity values from the known reference value. These plot show the error of each sensor as a function of humidity. The shaded grey region is the specified tolerance from the manufacturers' datasheets. All data collected, irrespective of temperature, are shown as blue dots. Red crosses are just those obtained at  $25\pm1^\circ\text{C}$ , so any that lie above or below the shaded region fail to meet the advertised specification. Where blue dots scatter outside the shaded region it indicates a drift in the calibration as a function of temperature. Red lines are quadratic fits to the  $25\pm1^\circ\text{C}$  data.

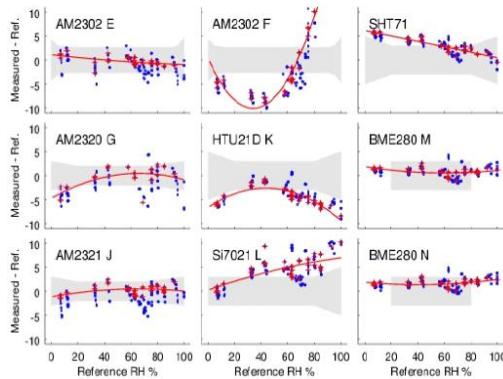


Figure 5 Plots showing the deviation of humidity values from the known reference value. [2]



## 1.4 Results for Temperature

The plot below is showing in red boxes and a linear fit line are measurements for all sensors with saturated ammonium nitrate over the temperature range 5–35°C. Plotted for comparison are values taken from the published literature. Cyan data from [O'Brien \(1948\)](#) and yellow from [Wexler \(1954\)](#). The thin black line is an equally weighted fit to both. [2]

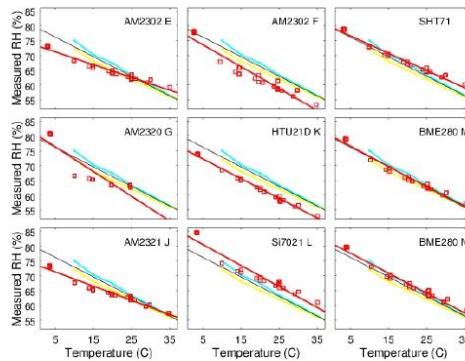


Figure 6 All sensors with saturated ammonium [2]

The plot below is showing as red boxes and a linear fit are measurements for all sensors with saturated magnesium chloride over the temperature range 5–35°C. Plotted for comparison are values taken from the published literature. Blue data are from [Greenspan \(1977\)](#), cyan data from [O'Brien \(1948\)](#), green from [Rockland \(1960\)](#), magenta are the [CRC Handbook \(1977\)](#) and yellow, [Wexler \(1954\)](#). The thin black line is an ensemble fit to them all, weighting all equally. [2]

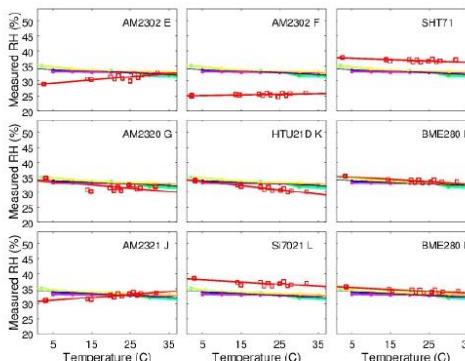


Figure 7 All sensors with saturated magnesium [2]



## 1.5 Function Simultaneously of Temperature and Humidity

Surfaces are showing deviation of each sensor from the true relative humidity as a function of temperature and humidity. A 'perfect' sensor would be a featureless green-yellow plane at zero. Blue shows low readings and red are high.

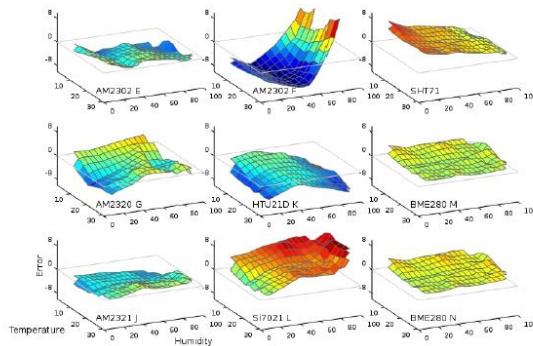


Figure 8 Temperature and Humidity [2]

## 1.6 Hysteresis

Deviations from the known reference value as humidity is systematically cycled from high to low and back to high. Two complete cycles of 92%, 60%, 33%, 7%, 33%, 60%, 92% are shown. For most sensors the traces followed on rising and falling humidity are reasonably close together, showing little hysteresis bias. A couple of sensors do show a strong effect. (Notes on particular sensors: AM2302 F output saturates at 99.9% for  $K_2NO_3$  so no values are plotted. The AM2321 generally failed to give any output for  $K_2NO_3$ . It occasionally provided an intermittent reading, but largely fails for humidity >90%. The AM2320 generally failed to give any output for  $NH_4NO_3$ . It occasionally provided an intermittent reading, but largely fails for humidities around 50-70%.)

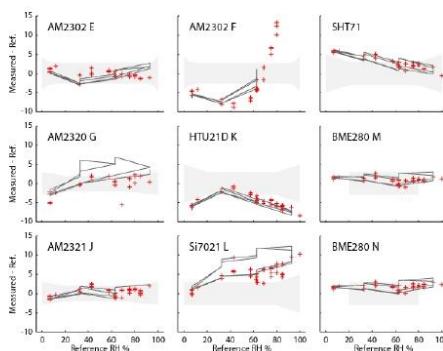


Figure 9 Deviations from the known reference value as humidity is systematically[2]



### 1.7. Response speed

Time response of the devices when exposed to a sudden upwards and downwards change in humidity. Left panel shows data directly from the sensors. Since the AM23xx devices return a previously cached value, they show the step change with a lag of one data point. In the right hand panel the lag has been arbitrarily removed and the values normalised in order to compare the intrinsic response speed of the sensor elements.

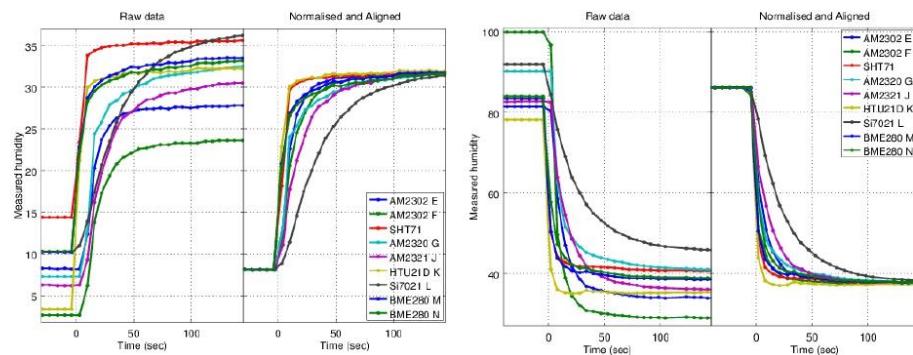


Figure 10 Time response of the devices when exposed to a sudden upwards and downwards change in humidity. [2]

### 1.8 Testing and evaluating

Overall the SHTxx sensor family is the best for the research project and because of that the final decision was made to be compared SHT31-D and SHT85 in real life situations. In the picture below are shown the inner of both of the sensors. In the left part is SHT85 and in the right side is SHT31-D.



Figure 11 Microscope pictures of the sensors



The pictures below are representing practical productions made specifically for experiments that follow. Furthermore there will be made the experiments and will be compared the characteristics of both of the sensors.

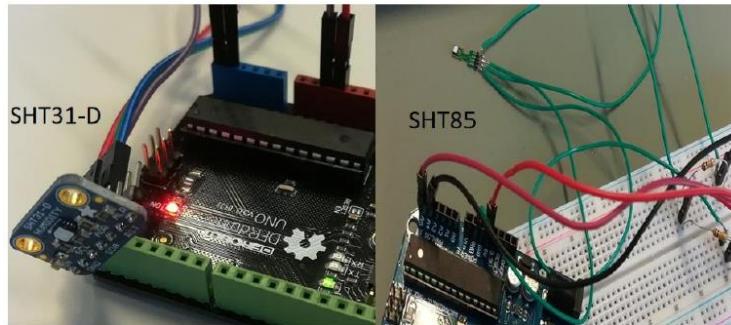


Figure 12 Practical productions

The experiments were done with SHT85, SHT31-D and also a measuring device with 99.8% accuracy. From the picture below is visible that SHT85 is more near by the real value and also it is faster at the normalizing the data flow. The SHT31-D has almost 0.30 degrees Celsius error from the real value and that it does not meet the requirements and needs of the project. Overall SHT85 it is with better characteristics and accuracy. Furthermore this sensor will be used in the building of the prototype.

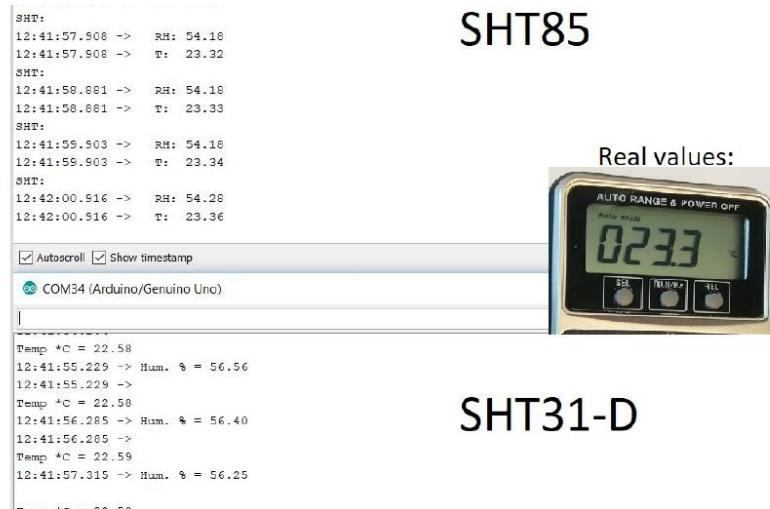


Figure 13 Results from experiments



## 2. Weight Sensor

The aim of this chapter is to define which sensor is most suitable for the research project. This has been done to up efficiency and the accuracy of the device that will be built.

The sensors are divided on 3 main categories – load cell, strain gauge and force-sensitive resistors. In this research will be test the characteristics and accuracy of two classes that are most accessible to the research team – load cells and FSRs.

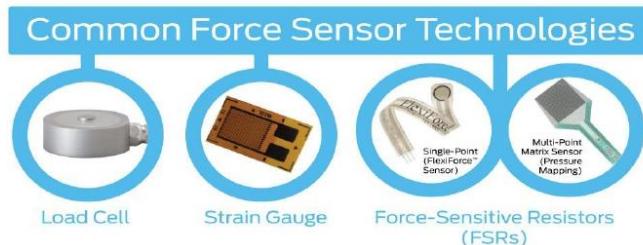


Figure 14 Types of common force sensors

### 2.1 Load Cell Basics

A load cell is a physical element (or transducer if you want to be technical) that can translate pressure (force) into an electrical signal.

#### 2.1.1 Hydraulic Load Cells

Hydraulic load cells use a conventional piston and cylinder arrangement to convey a change in pressure by the movement of the piston and a diaphragm arrangement which produces a change in the pressure on a Bourdon tube connected with the load cells.

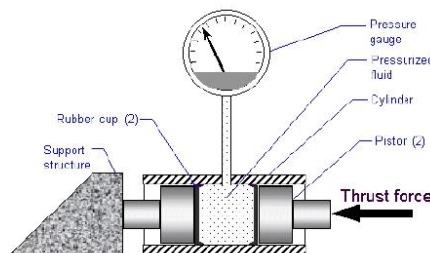


Figure 15 Diagram of a Hydraulic Load Cell [3]



### 2.1.2 Pneumatic Load Cells

Pneumatic load cells use air pressure applied to one end of a diaphragm, and it escapes through the nozzle placed at the bottom of the load cell, which has a pressure gauge inside of the cell.

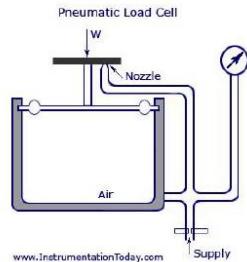


Figure 16 Diagram of a pneumatic load cell [4]

### 2.1.3 Strain Gauge Load Cells

And lastly (though there are many other less common load cell set ups), there is a strain gauge load cell, which is a mechanical element of which the force is being sensed by the deformation of a (or several) strain gauge(s) on the element.

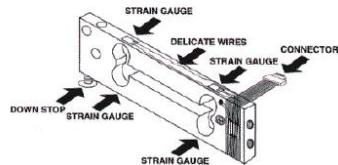


Figure 17 Strain gauge load cell diagram [5]

In bar strain gauge load cells, the cell is set up in a "Z" formation so that torque is applied to the bar and the four strain gauges on the cell will measure the bending distortion, two measuring compression and two tension. When these four strain gauges are set up in a wheatstone bridge formation, it is easy to accurately measure the small changes in resistance from the strain gauges. [5]

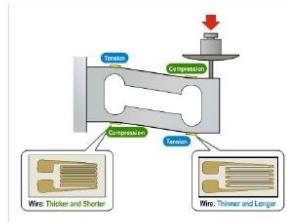


Figure 18 More in depth diagram of strain gauges on bar load cells when force is applied [5]



## 2.2 Testing and evaluating

### 2.2.1 Reference research

The experimental setup shown in the picture below was developed to measure the reflection of the hip force. The change in the sensed voltage from the Wheatstone Bridge of the two FSR sensors and the additional two resistances was measured with an AD converter during which a force was provided to the hip force sensing part. Three axis precision stages with a manual positioner that was able to move the sensing part and load cell with a precision of  $<1 \mu\text{m}$  were used to apply force to the sensing part with 1 mN resolution. The sensing part contacted the tip of the load cell and force was applied to it in each direction and at each position. b) shows the z-axis force measurement setup. Dynamic testing was performed using the measurement setup consisting of repeatedly loading and unloading the sensor 4 times. Identical measurements were performed for force applied to the z-, y- and x-axes [6]

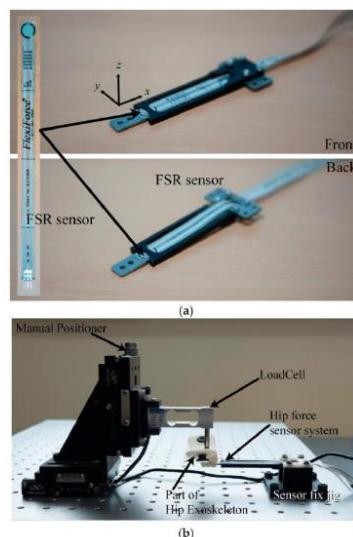


Figure 19 a) The developed sensor system and (b) force measurement and calibration system setup [6].

The picture below shows the experimental results of the relationship between the input force and the voltage variation of each sensor. a, b shows graphs of the relationship between the loading force on the z-axis and the measured voltage at the two sensors. For this system's structural characteristics, variation output occurred in one sensor when applying force to the system while the other sensor did not register any change. During the loading stage, the sensors followed the upper curve, while during the unloading stage, they followed the lower side of the curve. Subplot c-e shows graphs of the relationship between the loading force on the y- and x-axes and the measured voltage at the two sensors. The sensing accuracy is 1.5 N due to the nonlinearity of the FSR sensor and hysteresis of the sensor. The sensing accuracy is



below the Weber fraction, which is allowable for a wearable device, because a human cannot discriminate the force difference. [6]

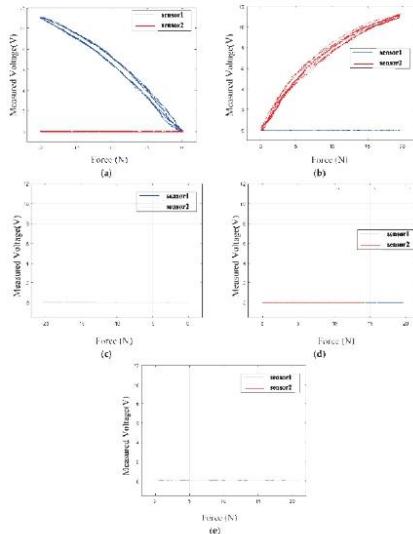


Figure 20 Experimental results of the relationship between the input force on the z-axis (a,b), the y-axis (c,d) and x-axis (e) and the voltage variation of each sensor. [6]

### 2.2.2 Applying the reference research

The experiments productions show in the pictures below are the prove of the hypothesis that FSR are not accurate enough and also that the load cell is the only class of weight sensors that meets the requirements of the research.

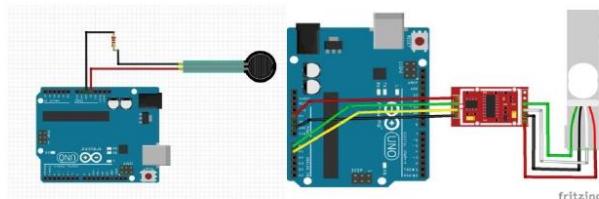


Figure 21 Productions for experiments

#### 2.2.2.1 FSR testing

In the pictures below is show the prototype that was made for testing the FSR . The object that is measured in that case is lighter with around 200-250 grams weight. From the test was finding out that the surface under the FSR sensor was in close relationship with the accuracy.



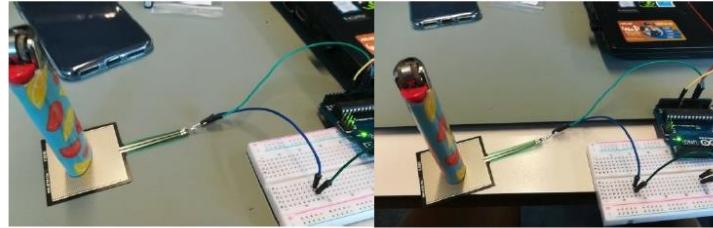


Figure 22 Experiments with FSR

Also the position of the lighter was in relationship with the accuracy of the sensor. Overall the FSR sensor is really not accurate as shown in the picture below because of the nonlinearity of the resistance.

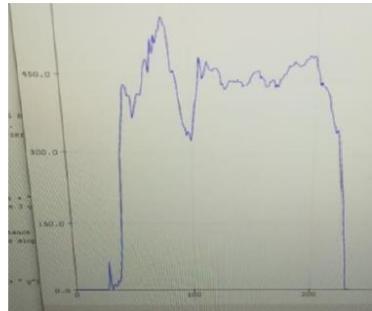


Figure 23 Results from FSR

#### 2.2.2.2 Load cell testing

The object of measurement of the test with the load cell was coin of 10 cent with 34 grams weigh. First experiment was done by measuring the coin in three different states - the moment when the coin was put, moment of stabilizing and normalizing the data and finally when the coin was taken out from the load cell. In the graph below are really visible the three states. And the result is with 99.8% accuracy.



Figure 24 Experiment with load cell and coin



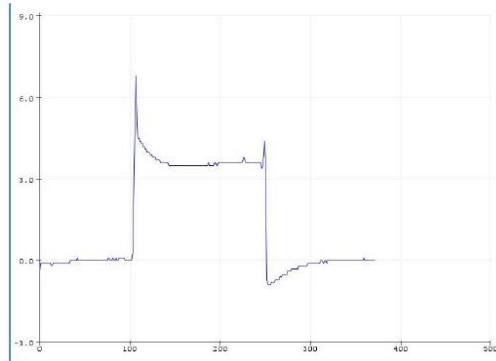


Figure 25 Results from load cell experiment

The second test was made with real predefined REVIT cup to finally test the accuracy of the sensor. And the results from the experiment is proves that this class of sensors are most suitable for this technical research.



Figure 26 Experiment with REVIT cup

### 3. Micro controllers

#### 3.1 Arduino UNO

The UNO is arguably the most popular Arduino. It is powered by an Atmega328 processor operating at 16MHz, includes 32KB of program memory, 1KB of EEPROM, 2KB of RAM, has 14 digital I/O, 6 analog inputs, and both 5V and 3.3V power rails.



Figure 27 Arduino UNO [7]



The Arduino UNO has a pin header arrangement that is rapidly becoming the industry standard for development boards, making it compatible with most development board shields on the market. A power jack is included on the UNO, allowing it to be powered by an external wall wart. There is also a VIN option available for connecting the UNO to batteries. The physical dimensions of the UNO (69mm x 54mm) make it a small development board that can easily fit into many projects and the four screw holes allow designers to securely fit them into place.

### 3.2 Arduino NANO

The Arduino Nano is essentially an Arduino UNO shrunk into a very small profile, making it very convenient for tight spaces and projects that may need to reduce weight wherever possible. Like the UNO, the Nano is powered by an Atmega328 processor operating at 16MHz, includes 32KB of program memory, 1KB of EEPROM, 2KB of RAM, has 14 digital I/O, 6 analog inputs, and both 5V and 3.3V power rails.

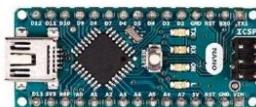


Figure 28 Arduino NANO [7]

The Nano, unlike the UNO, cannot connect to Arduino shields but it has pin headers which make it useful for breadboard prototyping or in PCBs with the use of a socket. Often, Arduino Nano boards are the cheapest Arduino board option available making them cost-effective for larger projects.

### 3.3 Arduino DUE

The Arduino Due is one of the larger boards and is also the first Arduino board to be powered by an ARM processor. While the UNO and Nano operate at 5V, the Due operates at 3.3V—this is important to note, because overvoltage will irreparably damage the board. Powered by an ATSAM3X8E Cortex-M3 running at 84MHz, the Due has 512KB of ROM and 96KB RAM, 54 digital I/O pins, 12 PWM channels, 12 analog inputs, and 2 analog outputs.



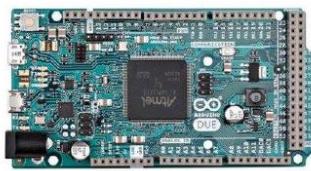


Figure 29 Arduino DUE [7]

The Due does not have any on-board EEPROM and is one of the more expensive Arduino boards. While the Due has a large number of pin headers for connecting to the many digital I/O, it is also pin-compatible with standard Arduino shields. Software compatibility with the Due cannot be guaranteed.

### 3.4 Arduino MEGA 2560

The Arduino Mega is somewhat similar to the Due in that it also has 54 I/O. However, instead of being powered by an ARM core, it instead uses an ATmega2560. The CPU is clocked at 16MHz and includes 256KB of ROM, 8KB of RAM, 4KB of EEPROM, and operates at 5V making it easy to use with most hobby friendly electronics.



Figure 30 Arduino MEGA [7]

The Arduino Mega has 16 analog inputs, 15 PWM channels, a pinout similar to the Due, and is hardware compatible with Arduino shields. Like the Due, software compatibility with the Mega cannot always be guaranteed.

### 3.5 Comparison

Arduino code can be easily transferred to different boards with virtually no changes which is highly beneficial to any designers wanting to change their mind about what board their project will use. The deciding factor each project will use comes down to two basic things: hardware and cost. While the cost aspect of each Arduino is obvious (the lowest cost option is always the preference), the hardware may not be so easy to determine. When looking at hardware the following should be considered:



- Physical dimensions
- CPU power
- Memory size
- I/O capabilities
- On-board peripherals
- Weight
- Connectivity

When it comes to physical dimensions the Arduino Nano is the smallest and is a very portable device. The UNO is a medium sized development board but is still small enough to be mounted to many projects including remote-controlled devices such as RC cars and boats. The Mega and Due are much larger boards which makes them difficult to use in space restricted applications.

Board	Best Applications	Example Projects
Arduino Nano	Low cost, small profile, simple projects	RC planes, portable electronics, and sensor gathering
Arduino Uno	Desktop prototyping and use with Arduino shields	Simple robot controller, RC cars, simple games console, IoT sensors, and device testing
Arduino Mega	High I/O requirements with more memory space	DIY bench tools, multi-device controlling, machine controller, home automation
Arduino Due	High performance prototyping with superior analog I/O	Data processor of multiple sources, home automation, machine controller

Figure 31 Comparison table

## 4. Architecture

The graphic below is representing the basic method of operation of the device that should be built in the end of these technical research. Basically there are 6 sensors for humidity and temperature and 6 sensors that are measuring the weight of the REVIT cup continuously. After that all of them send the raw data to microcontroller. Furthermore the raw data is normalize and is send to the firmware that will be discussed in next chapter.

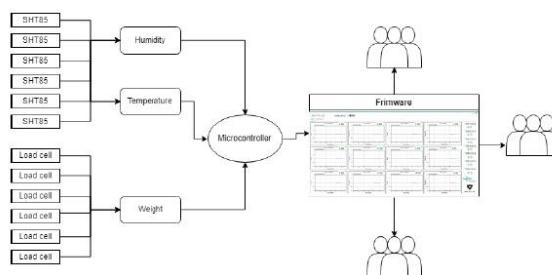


Figure 32 Method of operation



## 5. Graphical user interface

In the picture below is representing the concept how should look the final firmware. It should represent continuously the humidity and weight levels. Also to make log book of all the data that is received.



Figure 33 Firmware front page

The firmware has a window for establishing connection with the microcontroller. Also has dark mode that is making all of the components black and white. Only the graphs in dark mode are not going to be black. They will be gray.

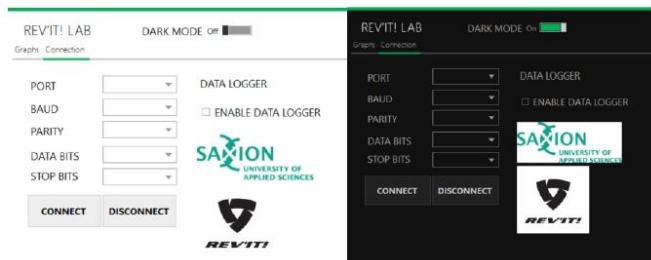


Figure 34 Firmware connection page



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- [7] Arduino. [Online]. Available: <https://www.arduino.cc>.



## 11.Drilling wholes

Because of the circumstances that one of our team members (Harold Kip) supposed to leave our team, we should finish his part of the work. His role was mainly mechanical, for example replicating the cups, drilling wholes, gluing cables and laser cutting. Anything related with his speciality. Because of this I supposed to drill all the holes in the cups. I was for first time in the Mechanical department and was new experience for me.



In the picture is visible where supposed to be drilled the holes and after that should be put a connectors for the SHT85 temperature humidity sensors.



When the holes are done and connectors are placed I connected the cables and glue the hole with connector and cables. I tried to make it as good as possible to be sure that the water/steam won't go out of the cup and to influence the whole experiment.



## 12. Software Development

The main device in the project is Arduino based and due to this fact are used Arduino IDE and the Arduino C to be programmed. The Arduino C is language developed especially for Atmel microcontroller and in the case of this project Arduino UNO. The language is mixture between C, C++ and some special libraries only for Arduino.

The black box below is representing the final version of the embedded software for the devices. In the code at the beginning are initialized all of weight sensors (LOADCELL-s) and also the SHT85 sensors. Also it is defining the calibration factor for the load cells that later on this will be define the accuracy of the device. The first rows are for implementing the libraries for the sensors.

However, in the loop part of the code firstly is collecting the data of the SHT85 sensors and if there is not data (NAN) that the code is defining the value as 0 and this means that the sensor is not responding. This can be caused from damage or disconnection from the main device. After that is collecting the data from the load cells and putting all of the data in one big sting that will be transfer via the COM port to the PC (to the Firmware).

In the end of the code are visible all of the functions for communicating and collecting data from the sensors. Also the function for using the I2C expander that is giving quince addresses to all of the SHT85 sensors. Otherwise all of them will have same address and they won't work or if they work they will mix their data and won't be possible to identify which data from which sensor it is.

```
#include <Wire.h>
#include "HX711.h"
#include "SHTSensor.h"
extern "C" {
    #include "utility/twi.h"
#define TCAADDR 0x70
```

```

#define LOADCELL_DOUT_PIN_1 3
#define LOADCELL_SCK_PIN_1 2
#define LOADCELL_DOUT_PIN_2 5
#define LOADCELL_SCK_PIN_2 4
#define LOADCELL_DOUT_PIN_3 7
#define LOADCELL_SCK_PIN_3 6
#define LOADCELL_DOUT_PIN_4 9
#define LOADCELL_SCK_PIN_4 8
#define LOADCELL_DOUT_PIN_5 11
#define LOADCELL_SCK_PIN_5 10
#define LOADCELL_DOUT_PIN_6 13
#define LOADCELL_SCK_PIN_6 12
HX711 scale[6];
SHTSensor sht[7];
void tcaselect(uint8_t i);
int reading_loadcell(int number);
void setupsh85(int index);
int temp(int index);
int hum(int index);
void setupscales(int index,int out, int sck);
float calibration_factor = -7050; // -7050 worked for my 440lb max scale setup
long reading_cell[6];
float temp_s[7];
float hum_s[7];
long zero_factor[6];
void setup()
{
    Serial.begin(9600);
    Wire.begin();
    setupscales(0,LOADCELL_DOUT_PIN_1, LOADCELL_SCK_PIN_1);
    setupscales(1,LOADCELL_DOUT_PIN_2, LOADCELL_SCK_PIN_2);
    setupscales(2,LOADCELL_DOUT_PIN_3, LOADCELL_SCK_PIN_3);
    setupscales(3,LOADCELL_DOUT_PIN_4, LOADCELL_SCK_PIN_4);
    setupscales(4,LOADCELL_DOUT_PIN_5, LOADCELL_SCK_PIN_5);
    setupscales(5,LOADCELL_DOUT_PIN_6, LOADCELL_SCK_PIN_6);
    for (int i = 0; i <= 6; i++)
    {
        setupsh85(i);
    }
}
void loop() {
    for (int j = 0; j <= 6; j++)
    {
        hum_s[j] = hum(j);
        temp_s[j]= temp(j);
    }
    for (int k = 0; k <= 5; k++)
    {
        reading_cell[k] = reading_loadcell(k);
    }
}

```



```

    }
    if(isnan(sht[0].getHumidity())){hum_s[0]=0;temp_s[0]=0;}
    else{hum_s[0]=sht[0].getHumidity();temp_s[0]=sht[0].getTemperature();}
    if(isnan(sht[1].getHumidity())){hum_s[1]=0;temp_s[1]=0;}
    else{hum_s[1]=sht[1].getHumidity();temp_s[1]=sht[1].getTemperature();}
    if(isnan(sht[2].getHumidity())){hum_s[2]=0;temp_s[2]=0;}
    else{hum_s[2]=sht[2].getHumidity();temp_s[2]=sht[2].getTemperature();}
    if(isnan(sht[3].getHumidity())){hum_s[3]=0;temp_s[3]=0;}
    else{hum_s[3]=sht[3].getHumidity();temp_s[3]=sht[3].getTemperature();}
    if(isnan(sht[4].getHumidity())){hum_s[4]=0;temp_s[4]=0;}
    else{hum_s[4]=sht[4].getHumidity();temp_s[4]=sht[4].getTemperature();}
    if(isnan(sht[5].getHumidity())){hum_s[5]=0;temp_s[5]=0;}
    else{hum_s[5]=sht[5].getHumidity();temp_s[5]=sht[5].getTemperature();}
    if(isnan(sht[6].getHumidity())){hum_s[6]=0;temp_s[6]=0;}
    else{hum_s[6]=sht[6].getHumidity();temp_s[6]=sht[6].getTemperature();}
    String H1 = String(hum_s[0]); String W1 = String(reading_cell[0]);String H
2 = String(hum_s[1]);
    String W2 = String(reading_cell[1]);String H3 = String(hum_s[2]);String W3
= String(reading_cell[2]);
    String H4 = String(hum_s[3]);String W4 = String(reading_cell[3]);String H5
= String(hum_s[4]);
    String W5 = String(reading_cell[4]);String H6 = String(hum_s[5]);String W6
= String(reading_cell[5]);
    String T0 = String(temp_s[6]);
    String T1 = String(temp_s[0]); String T2 = String(temp_s[1]); String T3 =
String(temp_s[2]);
    String T4 = String(temp_s[3]); String T5 = String(temp_s[4]);String T6 =
String(temp_s[5]);
    Serial.println(H1+" "+W1+" "+H2+" "+W2+" "+H3+" "+W3+" "+H4+" "+W4+" "+H5+
", "+W5+", "+H6+", "+W6+", "+T0+", "+T1+", "+T2+", "+T3+", "+T4+", "+T5+", "+T6);
    delay(300);
}
void tcaselect(uint8_t i)
{
    if (i > 7) return;
    Wire.beginTransmission(TCAADDR);
    Wire.write(1 << i);
    Wire.endTransmission();
}
int reading_loadcell(int number)
{
    float value = 0;
    scale[number].set_scale(calibration_factor);
    value = (((scale[number].get_units()*4.5359237)/2));
    return value;
}
void setupcales(int index,int out, int sck)
{

```



```

scale[index].begin(out, sck);
scale[index].set_scale();
scale[index].tare();
zero_factor[index] = scale[index].read_average();
}
void setupsht85(int index)
{
    tcaselect(index);
    sht[index].setAccuracy(SHTSensor::SHT_ACCURACY_MEDIUM);
    if (sht[index].init())
    { //Serial.println(F("Yes it is connected"));
    }
    else
    { //Serial.println(F("No it is not connected"));
    }
}
int temp(int index)
{
    long value_temp;
    tcaselect(index);
    if (sht[index].readSample())
    {
        value_temp = sht[index].getTemperature();
    }
    return value_temp;
}
int hum(int index)
{
    long value_hum;
    tcaselect(index);
    if (sht[index].readSample())
    {
        value_hum = sht[index].getHumidity();
    }
    return value_hum;
}

```

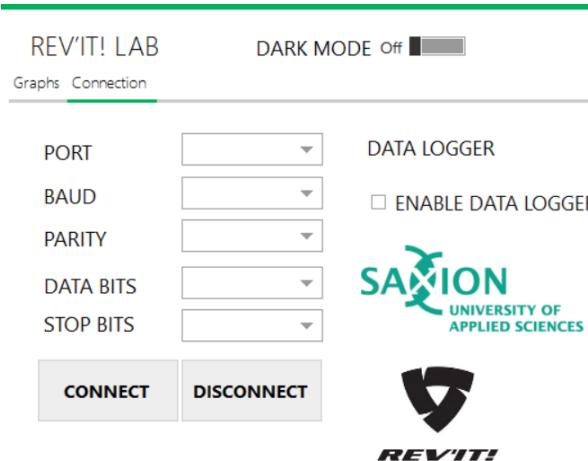
## 13. Software for firmware

The picture below is the visual representation of the code for the firmware. The client in the end will see only this representation. There are 12 graphs for the 6 cups (6 for weight sensors and 6 for the humidity of each of the cups). Also in right there is a column with temperature for each of the cups and also for the temperature of the oven.



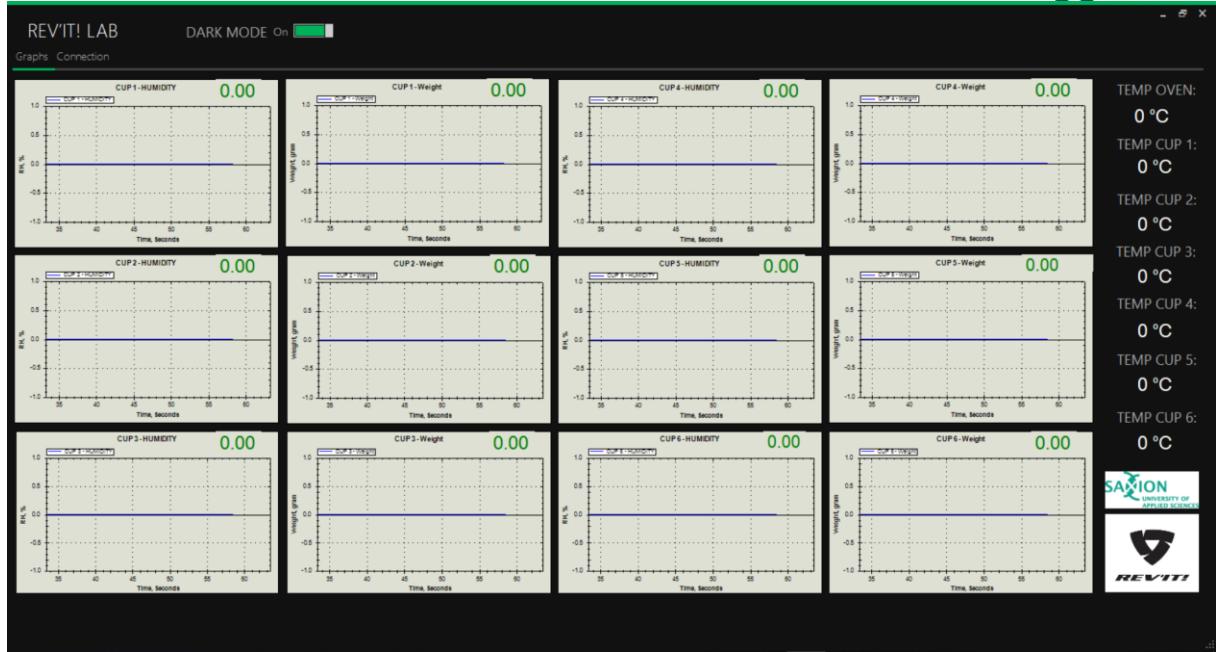


There is a second window that the client will establish the connection between the computer and the device. Also there is a feature that can log the data in a txt file. After that this txt file really easy can be transferred to excel or any other file format.

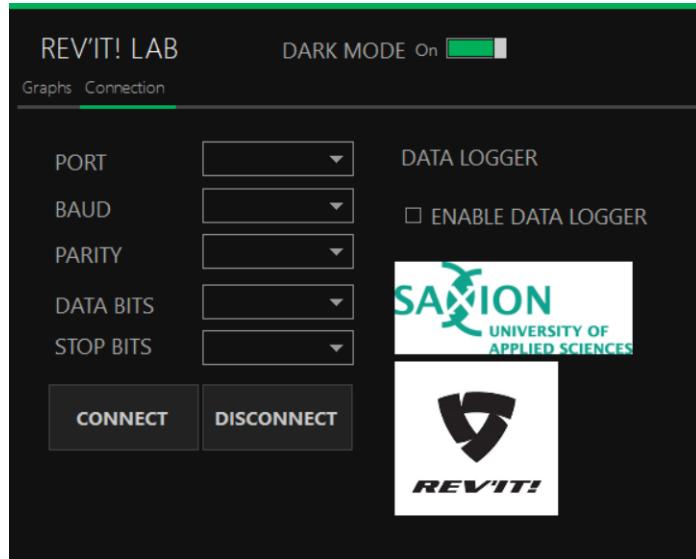


Also there is a dark mode for the graphs visualization. All of the components are going white and meanwhile the background is going black.





Also the dark mode is working in the connection windows. All of the components are change in black. Only the logos keep being white.



All of the functions described above are in the code below. The main logic of the code is following: the code is reading a string and separate it by special symbol in that case comma. And after that is representing the values in the graphs and the column for the temperature. Also there is a part that is establishing the connection between the computer and firmware.



```

using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
using System.IO.Ports;
using System.Diagnostics;
using System.Threading;
using System.Windows.Forms.DataVisualization.Charting;
using ZedGraph;

namespace FFD_GUI
{
    public partial class Main : MetroFramework.Forms.MetroForm
    {
        string[] arrList = new string[19];
        System.IO.StreamWriter out_file;
        class Settings
        {
            public string[] returndata = new string[65];
            public string[] Yaxis = new string[13];
            public string[] Xaxis = new string[13];
            public string[] Danger1 = new string[15];
            public string[] Danger2 = new string[15];
            public string[] Danger3 = new string[15];
            public string[] sensor_data = new string[13];
            public string[] calib = new string[13];
            public string[] calibbuff = new string[13];
        }
        class Datacon
        {
            public string[] rdata = new string[28];
            public string[] dataport_sensor = new string[28];
            public double[] data = new double[13];
        }
        Datacon d = new Datacon();
        Settings u = new Settings();
        //double temp = 0;
        //double humidity = 0;
        int TickStart1;
        int TickStart2;
        int TickStart3;
    }
}

```



```

        int TickStart4;
        int TickStart5;
        int TickStart6;
        int TickStart7;
        int TickStart8;
        int TickStart9;
        int TickStart10;
        int TickStart11;
        int TickStart12;

    public Main()
    {
        InitializeComponent();
        openFileDialog1.Filter = "Text (*.txt)";
        cbBaud.Items.Add(9600);
        cbBaud.Items.Add(14400);
        cbBaud.Items.Add(19200);
        cbBaud.Items.Add(38400);
        cbBaud.Items.Add(57600);
        cbBaud.Items.Add(74880);
        cbBaud.Items.Add(115200);
        cbBaud.Items.Add(230400);
        cbBaud.Items.Add(256000);
        cbBaud.Items.Add(460800);
        cbBaud.Items.Add(921600);

        cbDatabits.Items.Add(8);
        cbDatabits.Items.Add(7);
        cbDatabits.Items.Add(6);
        cbDatabits.Items.Add(5);

        cbStopbits.Items.Add("One");
        cbStopbits.Items.Add("OnePointFive");
        cbStopbits.Items.Add("Two");

        cbParity.Items.Add("None");
        cbParity.Items.Add("Even");
        cbParity.Items.Add("Odd");
        cbParity.Items.Add("Mark");
        cbParity.Items.Add("Space");
        lblsensor13.ForeColor = Color.Green;
        lblsensor14.ForeColor = Color.Green;
        lblsensor15.ForeColor = Color.Green;
        lblsensor16.ForeColor = Color.Green;
        lblsensor17.ForeColor = Color.Green;
        lblsensor18.ForeColor = Color.Green;
        lblsensor19.ForeColor = Color.Green;
        timer16.Tick += new EventHandler(DoUpdate); // Everytime timer tic
    }
}

```

```

        timer16.Enabled = true;
        timer15.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
            timer15.Enabled = true;
            timer2.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                timer2.Enabled = true; // Enable the timer
                timer2.Start(); // Start the timer
                timer1.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                    timer1.Enabled = true; // Enable the timer
                    timer1.Start();
                    timer3.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                        timer3.Enabled = true; // Enable the timer
                        timer3.Start(); // Start the timer
                        timer4.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                            timer4.Enabled = true; // Enable the timer
                            timer4.Start(); // Start the timer
                            timer5.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                timer5.Enabled = true; // Enable the timer
                                timer5.Start(); // Start the timer
                                timer6.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                    timer6.Enabled = true; // Enable the timer
                                    timer6.Start(); // Start the timer
                                    timer7.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                        timer7.Enabled = true; // Enable the timer
                                        timer7.Start(); // Start the timer
                                        timer8.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                            timer8.Enabled = true; // Enable the timer
                                            timer8.Start(); // Start the timer
                                            timer9.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                                timer9.Enabled = true; // Enable the timer
                                                timer9.Start(); // Start the timer
                                                timer10.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                                    timer10.Enabled = true; // Enable the timer
                                                    timer10.Start(); // Start the timer
                                                    timer11.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
                                                        timer11.Enabled = true; // Enable the timer
                                                        timer11.Start();

```

```

        timer11.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
            timer11.Enabled = true; // Enable the timer
            timer11.Start();
        timer12.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
            timer12.Enabled = true; // Enable the timer
            timer12.Start();
        timer13.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
            timer13.Enabled = true; // Enable the timer
            timer13.Start();
        timer14.Tick += new EventHandler(DoUpdate); // Everytime timer ticks, timer_Tick will be called
            timer14.Enabled = true; // Enable the timer
            timer14.Start();
    }

    public void DoUpdate(object sender, EventArgs e)
    {
    }
    private void connectionToolStripMenuItem_Click(object sender, EventArgs e)
    {
    }

    private void optionsToolStripMenuItem_Click(object sender, EventArgs e)
    {
    }

    private void aboutToolStripMenuItem_Click(object sender, EventArgs e)
    {
    }
    //
    private void Main_Load(object sender, EventArgs e)
    {
        this.StyleManager = metroStyleManager1;
        GraphPane myPanel1 = zedGraphControl1.GraphPane;
        myPanel1.Title.Text = "CUP 1 - HUMIDITY";
        myPanel1.XAxis.Title.Text = "Time, Seconds";
        myPanel1.YAxis.Title.Text = "RH, %";

        RollingPointPairList list1 = new RollingPointPairList(60000);
        LineItem Curve1 = myPanel1.AddCurve("CUP 1 - HUMIDITY", list1, Color.Blue, SymbolType.None);
        myPanel1.YAxis.Scale.MaxAuto = true;
        myPanel1.YAxis.Scale.MinAuto = true;
    }
}

```



```

myPane1.XAxis.Scale.MaxAuto = true;
myPane1.XAxis.Scale.MinAuto = true;
myPane1.XAxis.MajorGrid.Visible = true;
myPane1.YAxis.MajorGrid.Visible = true;
zedGraphControl1.AxisChange();
TickStart1 = Environment.TickCount;

GraphPane myPane2 = zedGraphControl2.GraphPane;
myPane2.Title.Text = "CUP 1 - Weight";
myPane2.XAxis.Title.Text = "Time, Seconds";
myPane2.YAxis.Title.Text = "Weight, gram";
myPane2.XAxis.MajorGrid.Visible = true;
myPane2.YAxis.MajorGrid.Visible = true;
RollingPointPairList list2 = new RollingPointPairList(60000);
LineItem Curve2 = myPane2.AddCurve("CUP 1 -
Weight", Color.Blue, SymbolType.None);
//
myPane2.YAxis.Scale.MaxAuto = true;
myPane2.YAxis.Scale.MinAuto = true;
myPane2.XAxis.Scale.MaxAuto = true;
myPane2.XAxis.Scale.MinAuto = true;

zedGraphControl2.AxisChange();
TickStart2 = Environment.TickCount;

/*Display the graph 3 of contents*/
//Theta graph/
GraphPane myPane3 = zedGraphControl3.GraphPane;
myPane3.Title.Text = "CUP 2 - HUMIDITY";
myPane3.XAxis.Title.Text = "Time, Seconds";
myPane3.YAxis.Title.Text = "RH, %";
myPane3.XAxis.MajorGrid.Visible = true;
myPane3.YAxis.MajorGrid.Visible = true;
RollingPointPairList list3 = new RollingPointPairList(60000);
LineItem Curve3 = myPane3.AddCurve("CUP 2 -
HUMIDITY", Color.Blue, SymbolType.None);

myPane3.YAxis.Scale.MaxAuto = true;
myPane3.YAxis.Scale.MinAuto = true;
myPane3.XAxis.Scale.MaxAuto = true;
myPane3.XAxis.Scale.MinAuto = true;

zedGraphControl3.AxisChange();
TickStart3 = Environment.TickCount;

GraphPane myPane4 = zedGraphControl4.GraphPane;
myPane4.Title.Text = "CUP 2 - Weight";
myPane4.XAxis.Title.Text = "Time, Seconds";
myPane4.YAxis.Title.Text = "Weight, gram";

```



```

myPane4.XAxis.MajorGrid.Visible = true;
myPane4.YAxis.MajorGrid.Visible = true;
RollingPointPairList list4 = new RollingPointPairList(60000);
LineItem Curve4 = myPane4.AddCurve("CUP 2 - 
Weight", list4, Color.Blue, SymbolType.None);

myPane4.YAxis.Scale.MaxAuto = true;
myPane4.YAxis.Scale.MinAuto = true;
myPane4.XAxis.Scale.MaxAuto = true;
myPane4.XAxis.Scale.MinAuto = true;

zedGraphControl4.AxisChange();
TickStart4 = Environment.TickCount;

GraphPane myPane5 = zedGraphControl5.GraphPane;
myPane5.Title.Text = "CUP 3 - HUMIDITY";
myPane5.XAxis.Title.Text = "Time, Seconds";
myPane5.YAxis.Title.Text = "RH, %";
myPane5.XAxis.MajorGrid.Visible = true;
myPane5.YAxis.MajorGrid.Visible = true;
RollingPointPairList list5 = new RollingPointPairList(60000);
LineItem Curve5 = myPane5.AddCurve("CUP 3 - 
HUMIDITY", list5, Color.Blue, SymbolType.None);

myPane5.YAxis.Scale.MaxAuto = true;
myPane5.YAxis.Scale.MinAuto = true;
myPane5.XAxis.Scale.MaxAuto = true;
myPane5.XAxis.Scale.MinAuto = true;

zedGraphControl5.AxisChange();
TickStart5 = Environment.TickCount;

GraphPane myPane6 = zedGraphControl6.GraphPane;
myPane6.Title.Text = "CUP 3 - Weight";
myPane6.XAxis.Title.Text = "Time, Seconds";
myPane6.YAxis.Title.Text = "Weight, gram";
myPane6.XAxis.MajorGrid.Visible = true;
myPane6.YAxis.MajorGrid.Visible = true;
RollingPointPairList list6 = new RollingPointPairList(60000);
LineItem Curve6 = myPane6.AddCurve("CUP 3 - 
Weight", list6, Color.Blue, SymbolType.None);

myPane6.YAxis.Scale.MaxAuto = true;
myPane6.YAxis.Scale.MinAuto = true;
myPane6.XAxis.Scale.MaxAuto = true;
myPane6.XAxis.Scale.MinAuto = true;

```

```

zedGraphControl6.AxisChange();
TickStart6 = Environment.TickCount;

GraphPane myPane7 = zedGraphControl7.GraphPane;
myPane7.Title.Text = "CUP 4 - HUMIDITY";
myPane7.XAxis.Title.Text = "Time, Seconds";
myPane7.YAxis.Title.Text = "RH, %";
myPane7.XAxis.MajorGrid.Visible = true;
myPane7.YAxis.MajorGrid.Visible = true;
RollingPointPairList list7 = new RollingPointPairList(60000);
LineItem Curve7 = myPane7.AddCurve("CUP 4 -
HUMIDITY", Color.Blue, SymbolType.None);

myPane7.YAxis.Scale.MaxAuto = true;
myPane7.YAxis.Scale.MinAuto = true;
myPane7.XAxis.Scale.MaxAuto = true;
myPane7.XAxis.Scale.MinAuto = true;

zedGraphControl7.AxisChange();
TickStart7 = Environment.TickCount;

GraphPane myPane8 = zedGraphControl8.GraphPane;
myPane8.Title.Text = "CUP 4 - Weight";
myPane8.XAxis.Title.Text = "Time, Seconds";
myPane8.YAxis.Title.Text = "Weight, gram";
myPane8.XAxis.MajorGrid.Visible = true;
myPane8.YAxis.MajorGrid.Visible = true;
RollingPointPairList list8 = new RollingPointPairList(60000);
LineItem Curve8 = myPane8.AddCurve("CUP 4 -
Weight", Color.Blue, SymbolType.None);

myPane8.YAxis.Scale.MaxAuto = true;
myPane8.YAxis.Scale.MinAuto = true;
myPane8.XAxis.Scale.MaxAuto = true;
myPane8.XAxis.Scale.MinAuto = true;

zedGraphControl8.AxisChange();
TickStart8 = Environment.TickCount;

GraphPane myPane9 = zedGraphControl9.GraphPane;
myPane9.Title.Text = "CUP 5 - HUMIDITY";
myPane9.XAxis.Title.Text = "Time, Seconds";
myPane9.YAxis.Title.Text = "RH, %";
myPane9.XAxis.MajorGrid.Visible = true;
myPane9.YAxis.MajorGrid.Visible = true;
RollingPointPairList list9 = new RollingPointPairList(60000);

```

```

        LineItem Curve9 = myPane9.AddCurve("CUP 5 -  

HUMIDITY", list9, Color.Blue, SymbolType.None);

myPane9.YAxis.Scale.MaxAuto = true;  

myPane9.YAxis.Scale.MinAuto = true;  

myPane9.XAxis.Scale.MaxAuto = true;  

myPane9.XAxis.Scale.MinAuto = true;

zedGraphControl9.AxisChange();
TickStart9 = Environment.TickCount;

GraphPane myPane10 = zedGraphControl10.GraphPane;
myPane10.Title.Text = "CUP 5 - Weight";
myPane10.XAxis.Title.Text = "Time, Seconds";
myPane10.YAxis.Title.Text = "Weight, gram";
myPane10.XAxis.MajorGrid.Visible = true;
myPane10.YAxis.MajorGrid.Visible = true;
RollingPointPairList list10 = new RollingPointPairList(60000);
LineItem Curve10 = myPane10.AddCurve("CUP 5 -  

Weight", list10, Color.Blue, SymbolType.None);

```

```

myPane10.YAxis.Scale.MaxAuto = true;  

myPane10.YAxis.Scale.MinAuto = true;  

myPane10.XAxis.Scale.MaxAuto = true;  

myPane10.XAxis.Scale.MinAuto = true;

zedGraphControl10.AxisChange();
TickStart10 = Environment.TickCount;

GraphPane myPane11 = zedGraphControl11.GraphPane;
myPane11.Title.Text = "CUP 6 - HUMIDITY";
myPane11.XAxis.Title.Text = "Time, Seconds";
myPane11.YAxis.Title.Text = "RH, %";
myPane11.XAxis.MajorGrid.Visible = true;
myPane11.YAxis.MajorGrid.Visible = true;
RollingPointPairList list11 = new RollingPointPairList(60000);
LineItem Curve11 = myPane11.AddCurve("CUP 6 -  

HUMIDITY", list11, Color.Blue, SymbolType.None);

```

```

myPane11.YAxis.Scale.MaxAuto = true;  

myPane11.YAxis.Scale.MinAuto = true;  

myPane11.XAxis.Scale.MaxAuto = true;  

myPane11.XAxis.Scale.MinAuto = true;

```

```

zedGraphControl11.AxisChange();
TickStart11 = Environment.TickCount;

GraphPane myPane12 = zedGraphControl12.GraphPane;
myPane12.Title.Text = "CUP 6 - Weight";
myPane12.XAxis.Title.Text = "Time, Seconds";
myPane12.YAxis.Title.Text = "Weight, gram";
myPane12.XAxis.MajorGrid.Visible = true;
myPane12.YAxis.MajorGrid.Visible = true;
RollingPointPairList list12 = new RollingPointPairList(60000);
LineItem Curve12 = myPane12.AddCurve("CUP 6 -
Weight", list12, Color.Blue, SymbolType.None);

myPane12.YAxis.Scale.MaxAuto = true;
myPane12.YAxis.Scale.MinAuto = true;
myPane12.XAxis.Scale.MaxAuto = true;
myPane12.XAxis.Scale.MinAuto = true;
zedGraphControl12.AxisChange();
TickStart12 = Environment.TickCount;
}

private void Connection_Load(object sender, EventArgs e)
{
    cbBaud.Enabled = true;
    cbPorts.Enabled = true;
    cbDatabits.Enabled = true;
    cbStopbits.Enabled = true;
    cbParity.Enabled = true;
    //Disable button control

    //Load value//
    cbBaud.Items.Add(9600);
    cbBaud.Items.Add(14400);
    cbBaud.Items.Add(19200);
    cbBaud.Items.Add(38400);
    cbBaud.Items.Add(57600);
    cbBaud.Items.Add(74880);
    cbBaud.Items.Add(115200);
    cbBaud.Items.Add(230400);
    cbBaud.Items.Add(256000);
    cbBaud.Items.Add(460800);
    cbBaud.Items.Add(921600);

    cbDatabits.Items.Add(8);
    cbDatabits.Items.Add(7);
    cbDatabits.Items.Add(6);
    cbDatabits.Items.Add(5);

    cbStopbits.Items.Add("One");
}

```



```

        cbStopbits.Items.Add("OnePointFive");
        cbStopbits.Items.Add("Two");

        cbParity.Items.Add("None");
        cbParity.Items.Add("Even");
        cbParity.Items.Add("Odd");
        cbParity.Items.Add("Mark");
        cbParity.Items.Add("Space");
        btnDisConn.Enabled = false;
    }

    private void serialPort1_DataReceived(object sender, SerialDataReceivedEventArgs e)
    {
        try
        {
            //split data receive from serialport
            arrList = serialPort1.ReadLine().Split(',');
        }

        catch
        {
            return;
        }
    }

    private void BtnConn_Click(object sender, EventArgs e)
    {

    }

    private void BtnDisConn_Click(object sender, EventArgs e)
    {

    }

    private void Datalogger_checkbox_CheckedChanged(object sender, EventArgs e)
    {
    }

    public void logger_saveinfo()
    {
        try
        {
            using (System.IO.StreamWriter file =
new System.IO.StreamWriter(@datalogger_checkbox.Text, true))
            {
                string year = DateTime.Now.Year.ToString("0000");
                string month = DateTime.Now.Month.ToString("00");
                string date = DateTime.Now.Day.ToString("00");
                string hour = DateTime.Now.Hour.ToString("00");
                string minute = DateTime.Now.Minute.ToString("00");
                string second = DateTime.Now.Second.ToString("00");
            }
        }
    }
}

```

```

        string CurrentDate = date + "/" + month + "/" + year + " || " + ho
ur + ":" + minute + ":" + second;
        file.WriteLine(CurrentDate + "," + arrList[0] + "," + arrList[1]
+ "," + arrList[2] + "," + arrList[3] + "," + arrList[4] + "," + arrList[5] +
"," + arrList[6] + "," + arrList[7] + "," + arrList[8] + "," + arrList[9] + "
," + arrList[10] + "," + arrList[11] + "," + arrList[12] + "," + arrList[13] +
"," + arrList[14] + "," + arrList[15] + "," + arrList[16] + "," + arrList[17]
+ "," + arrList[18] + "\n");
    }
}

catch
{
    return;
}
}

int intlen = 0;
private void Timer15_Tick(object sender, EventArgs e)
{
    logger_saveinfo();
}
private void Timer16_Tick(object sender, EventArgs e)
{

}
private void Chart1_Click(object sender, EventArgs e)
{
}

private void Chart14_Click(object sender, EventArgs e)
{
}

private void Lbl_Click(object sender, EventArgs e)
{
}

private void Button2_Click(object sender, EventArgs e)
{
}

private void ToolStripMenuItem2_Click(object sender, EventArgs e)
{
}

private void MenuStrip2_ItemClicked(object sender, ToolStripItemClicked
EventArgs e)

```

```

    }

    private void CpuChart_Click(object sender, EventArgs e)
    {

    }

    private void Timer1_Tick(object sender, EventArgs e)
    {


        Draw();
        lblsensor1.ForeColor = Color.Green;
        lblsensor1.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[0]));
        lblsensor2.ForeColor = Color.Green;
        lblsensor2.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[1]));
        lblsensor3.ForeColor = Color.Green;
        lblsensor3.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[7]));
        lblsensor4.ForeColor = Color.Green;
        lblsensor4.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[3]));
        lblsensor5.ForeColor = Color.Green;
        lblsensor5.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[4]));
        lblsensor6.ForeColor = Color.Green;
        lblsensor6.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[5]));
        lblsensor7.ForeColor = Color.Green;
        lblsensor7.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[6]));
        lblsensor8.ForeColor = Color.Green;
        lblsensor8.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[2]));
        lblsensor9.ForeColor = Color.Green;
        lblsensor9.Text = String.Format("{0:0.00}", Convert.ToDouble(arrLi
st[8]));
        lblsensor10.ForeColor = Color.Green;
        lblsensor10.Text = String.Format("{0:0.00}", Convert.ToDouble(arrL
ist[9]));
        lblsensor11.ForeColor = Color.Green;
        lblsensor11.Text = String.Format("{0:0.00}", Convert.ToDouble(arrL
ist[10]));
        lblsensor12.ForeColor = Color.Green;
    }
}

```



```

        lblsensor12.Text = String.Format("{0:0.00}", Convert.ToDouble(arrL
ist[11]));
        lblsensor13.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[12]));
        lblsensor14.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[13]));
        lblsensor15.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[14]));
        lblsensor16.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[15]));
        lblsensor17.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[16]));
        lblsensor18.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[17]));
        lblsensor19.Text = String.Format("{0} °C", Convert.ToDouble(arrLis
t[18]));

    }

private void ChartTest_Click(object sender, EventArgs e)
{
}

private void Draw()
{
    if (zedGraphControl1.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl2.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl3.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl4.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl5.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl6.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl7.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl8.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl9.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl10.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl11.GraphPane.CurveList.Count <= 0)
        return;
    if (zedGraphControl12.GraphPane.CurveList.Count <= 0)
        return;
}

```



```
        LineItem curve1 = zedGraphControl1.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve2 = zedGraphControl2.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve3 = zedGraphControl3.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve4 = zedGraphControl4.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve5 = zedGraphControl5.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve6 = zedGraphControl6.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve7 = zedGraphControl7.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve8 = zedGraphControl8.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve9 = zedGraphControl9.GraphPane.CurveList[0] as LineI
tem;
        LineItem curve10 = zedGraphControl10.GraphPane.CurveList[0] as Lin
eItem;
        LineItem curve11 = zedGraphControl11.GraphPane.CurveList[0] as Lin
eItem;
        LineItem curve12 = zedGraphControl12.GraphPane.CurveList[0] as Lin
eItem;

        if (curve1 == null)
            return;
        if (curve2 == null)
            return;
        if (curve3 == null)
            return;
        if (curve4 == null)
            return;
        if (curve5 == null)
            return;
        if (curve6 == null)
            return;
        if (curve7 == null)
            return;
        if (curve8 == null)
            return;
        if (curve9 == null)
            return;
        if (curve10 == null)
            return;
        if (curve11 == null)
            return;
```



```

        if (curve12 == null)
            return;
        //
        IPointListEdit list1 = curve1.Points as IPointListEdit;
        IPointListEdit list2 = curve2.Points as IPointListEdit;
        IPointListEdit list3 = curve3.Points as IPointListEdit;
        IPointListEdit list4 = curve4.Points as IPointListEdit;
        IPointListEdit list5 = curve5.Points as IPointListEdit;
        IPointListEdit list6 = curve6.Points as IPointListEdit;
        IPointListEdit list7 = curve7.Points as IPointListEdit;
        IPointListEdit list8 = curve8.Points as IPointListEdit;
        IPointListEdit list9 = curve9.Points as IPointListEdit;
        IPointListEdit list10 = curve10.Points as IPointListEdit;
        IPointListEdit list11 = curve11.Points as IPointListEdit;
        IPointListEdit list12 = curve12.Points as IPointListEdit;
        //
        if (list1 == null)
            return;
        if (list2 == null)
            return;
        if (list3 == null)
            return;
        if (list4 == null)
            return;
        if (list5 == null)
            return;
        if (list6 == null)
            return;
        if (list7 == null)
            return;
        if (list8 == null)
            return;
        if (list9 == null)
            return;
        if (list10 == null)
            return;
        if (list11 == null)
            return;
        if (list12 == null)
            return;
        //
        double time1 = (EnvironmentTickCount - TickStart1) / 1000.0;
        double time2 = (EnvironmentTickCount - TickStart2) / 1000.0;
        double time3 = (EnvironmentTickCount - TickStart3) / 1000.0;
        double time4 = (EnvironmentTickCount - TickStart4) / 1000.0;
        double time5 = (EnvironmentTickCount - TickStart5) / 1000.0;
        double time6 = (EnvironmentTickCount - TickStart6) / 1000.0;
        double time7 = (EnvironmentTickCount - TickStart7) / 1000.0;
        double time8 = (EnvironmentTickCount - TickStart8) / 1000.0;
    
```



```

        double time9 = (Environment.TickCount - TickStart9) / 1000.0;
        double time10 = (Environment.TickCount - TickStart10) / 1000.0;
        double time11 = (Environment.TickCount - TickStart11) / 1000.0;
        double time12 = (Environment.TickCount - TickStart12) / 1000.0;
        //
        list1.Add(time1, Convert.ToDouble(arrList[0]));
        list2.Add(time2, Convert.ToDouble(arrList[1]));
        list3.Add(time3, Convert.ToDouble(arrList[2]));
        list4.Add(time4, Convert.ToDouble(arrList[3]));
        list5.Add(time5, Convert.ToDouble(arrList[4]));
        list6.Add(time6, Convert.ToDouble(arrList[5]));
        list7.Add(time7, Convert.ToDouble(arrList[6]));
        list8.Add(time8, Convert.ToDouble(arrList[7]));
        list9.Add(time9, Convert.ToDouble(arrList[8]));
        list10.Add(time10, Convert.ToDouble(arrList[9]));
        list11.Add(time11, Convert.ToDouble(arrList[10]));
        list12.Add(time12, Convert.ToDouble(arrList[11]));

        Scale xScale1 = zedGraphControl1.GraphPane.XAxis.Scale;
        Scale xScale2 = zedGraphControl2.GraphPane.XAxis.Scale;
        Scale xScale3 = zedGraphControl3.GraphPane.XAxis.Scale;
        Scale xScale4 = zedGraphControl4.GraphPane.XAxis.Scale;
        Scale xScale5 = zedGraphControl5.GraphPane.XAxis.Scale;
        Scale xScale6 = zedGraphControl6.GraphPane.XAxis.Scale;
        Scale xScale7 = zedGraphControl7.GraphPane.XAxis.Scale;
        Scale xScale8 = zedGraphControl8.GraphPane.XAxis.Scale;
        Scale xScale9 = zedGraphControl9.GraphPane.XAxis.Scale;
        Scale xScale10 = zedGraphControl10.GraphPane.XAxis.Scale;
        Scale xScale11 = zedGraphControl11.GraphPane.XAxis.Scale;
        Scale xScale12 = zedGraphControl12.GraphPane.XAxis.Scale;
        //
        Scale yScale1 = zedGraphControl1.GraphPane.YAxis.Scale;
        Scale yScale2 = zedGraphControl2.GraphPane.YAxis.Scale;
        Scale yScale3 = zedGraphControl3.GraphPane.YAxis.Scale;
        Scale yScale4 = zedGraphControl4.GraphPane.YAxis.Scale;
        Scale yScale5 = zedGraphControl5.GraphPane.YAxis.Scale;
        Scale yScale6 = zedGraphControl6.GraphPane.YAxis.Scale;
        Scale yScale7 = zedGraphControl7.GraphPane.YAxis.Scale;
        Scale yScale8 = zedGraphControl8.GraphPane.YAxis.Scale;
        Scale yScale9 = zedGraphControl9.GraphPane.YAxis.Scale;
        Scale yScale10 = zedGraphControl10.GraphPane.YAxis.Scale;
        Scale yScale11 = zedGraphControl11.GraphPane.YAxis.Scale;
        Scale yScale12 = zedGraphControl12.GraphPane.YAxis.Scale;

        //
        if (time1 > xScale1.Max - xScale1.MajorStep)
        {
            xScale1.Max = time1 + xScale1.MajorStep;
        }
    }
}

```



```

        xScale1.Min = xScale1.Max -
30;//Auto scale x axis in limit tim
    }
    if (time2 > xScale2.Max - xScale2.MajorStep)
    {
        xScale2.Max = time2 + xScale2.MajorStep;
        xScale2.Min = xScale2.Max - 30;
    }
    if (time3 > xScale3.Max - xScale3.MajorStep)
    {
        xScale3.Max = time3 + xScale3.MajorStep;
        xScale3.Min = xScale3.Max - 30;
    }
    if (time4 > xScale4.Max - xScale4.MajorStep)
    {
        xScale4.Max = time4 + xScale4.MajorStep;
        xScale4.Min = xScale4.Max - 30;
    }
    if (time5 > xScale5.Max - xScale5.MajorStep)
    {
        xScale5.Max = time5 + xScale5.MajorStep;
        xScale5.Min = xScale5.Max - 30;
    }
    if (time6 > xScale6.Max - xScale6.MajorStep)
    {
        xScale6.Max = time6 + xScale6.MajorStep;
        xScale6.Min = xScale6.Max - 30;
    }
    if (time7 > xScale7.Max - xScale7.MajorStep)
    {
        xScale7.Max = time7 + xScale7.MajorStep;
        xScale7.Min = xScale7.Max - 30;
    }
    if (time8 > xScale8.Max - xScale8.MajorStep)
    {
        xScale8.Max = time8 + xScale8.MajorStep;
        xScale8.Min = xScale8.Max - 30;
    }
    if (time9 > xScale9.Max - xScale9.MajorStep)
    {
        xScale9.Max = time9 + xScale9.MajorStep;
        xScale9.Min = xScale9.Max - 30;
    }
    if (time10 > xScale10.Max - xScale10.MajorStep)
    {
        xScale10.Max = time10 + xScale10.MajorStep;
        xScale10.Min = xScale10.Max - 30;
    }
    if (time11 > xScale11.Max - xScale11.MajorStep)

```



```

    {
        xScale11.Max = time11 + xScale11.MajorStep;
        xScale11.Min = xScale11.Max - 30;
    }
    if (time12 > xScale12.Max - xScale12.MajorStep)
    {
        xScale12.Max = time12 + xScale12.MajorStep;
        xScale12.Min = xScale12.Max - 30;
    }

    //
    zedGraphControl1.AxisChange();
    zedGraphControl2.AxisChange();
    zedGraphControl3.AxisChange();
    zedGraphControl4.AxisChange();
    zedGraphControl5.AxisChange();
    zedGraphControl6.AxisChange();
    zedGraphControl7.AxisChange();
    zedGraphControl8.AxisChange();
    zedGraphControl9.AxisChange();
    zedGraphControl10.AxisChange();
    zedGraphControl11.AxisChange();
    zedGraphControl12.AxisChange();
    //
    zedGraphControl1.Invalidate();
    zedGraphControl2.Invalidate();
    zedGraphControl3.Invalidate();
    zedGraphControl4.Invalidate();
    zedGraphControl5.Invalidate();
    zedGraphControl6.Invalidate();
    zedGraphControl7.Invalidate();
    zedGraphControl8.Invalidate();
    zedGraphControl9.Invalidate();
    zedGraphControl10.Invalidate();
    zedGraphControl11.Invalidate();
    zedGraphControl12.Invalidate();

}

private void ZedGraphControl1_Load(object sender, EventArgs e)
{
}

private void Lbssensor13_Click(object sender, EventArgs e)
{
}

```



```
private void Timer2_Tick(object sender, EventArgs e)
{
}

private void PictureBox3_Click(object sender, EventArgs e)
{
    System.Diagnostics.Process.Start("https://www.saxion.nl/onderzoek/
smart-industry/advanced-forensic-technology");
}
private void Label63_Click(object sender, EventArgs e)
{
}

private void Label1_Click(object sender, EventArgs e)
{
}

private void Lbsensor15_Click(object sender, EventArgs e)
{
}

private void Timer3_Tick(object sender, EventArgs e)
{
    GraphPane myPane1 = zedGraphControl1.GraphPane;
}

private void Timer4_Tick(object sender, EventArgs e)
{
    GraphPane myPane2 = zedGraphControl2.GraphPane;
}

private void Timer5_Tick(object sender, EventArgs e)
{
    GraphPane myPane3 = zedGraphControl3.GraphPane;
}

private void Timer6_Tick(object sender, EventArgs e)
{
    GraphPane myPane4 = zedGraphControl4.GraphPane;
}

private void Timer7_Tick(object sender, EventArgs e)
{
    GraphPane myPane5 = zedGraphControl5.GraphPane;
}
```



```

private void Timer8_Tick(object sender, EventArgs e)
{
    GraphPane myPane6 = zedGraphControl6.GraphPane;
}

private void Timer9_Tick(object sender, EventArgs e)
{
    GraphPane myPane7 = zedGraphControl7.GraphPane;
}

private void Timer10_Tick(object sender, EventArgs e)
{
    GraphPane myPane8 = zedGraphControl8.GraphPane;
}

private void Timer11_Tick(object sender, EventArgs e)
{
    GraphPane myPane9 = zedGraphControl9.GraphPane;
}

private void Timer12_Tick(object sender, EventArgs e)
{
    GraphPane myPane10 = zedGraphControl10.GraphPane;
}

private void Timer13_Tick(object sender, EventArgs e)
{
    GraphPane myPane11 = zedGraphControl11.GraphPane;
}

private void Timer14_Tick(object sender, EventArgs e)
{
    GraphPane myPane12 = zedGraphControl12.GraphPane;
}

private void ZedGraphControl5_Load(object sender, EventArgs e)
{

}

private void MetroProgressBar1_Click(object sender, EventArgs e)
{
}

bool drum;
private void MetroToggle1_CheckedChanged(object sender, EventArgs e)
{
    if(drum == true)
    {
}

```



```

        metroStyleManager1.Theme = MetroFramework.MetroThemeStyle.Light;
        zedGraphControl1.GraphPane.Fill = new Fill(Color.FromArgb(255,
255,255));
        zedGraphControl1.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255,255,255));
        zedGraphControl2.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl2.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl3.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl3.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl4.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl4.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl5.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl5.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl6.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl6.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl7.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl7.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl8.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl8.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl9.GraphPane.Fill = new Fill(Color.FromArgb(255,
255, 255));
        zedGraphControl9.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl10.GraphPane.Fill = new Fill(Color.FromArgb(255
, 255, 255));
        zedGraphControl10.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl11.GraphPane.Fill = new Fill(Color.FromArgb(255
, 255, 255));
        zedGraphControl11.GraphPane.Chart.Fill = new Fill(Color.FromArgb(
255, 255, 255));
        zedGraphControl12.GraphPane.Fill = new Fill(Color.FromArgb(255
, 255, 255));
    
```



```

zedGraphControl12.GraphPane.Chart.Fill = new Fill(Color.FromArgb(255, 255, 255));
    lblsensor1.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor2.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor3.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor4.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor5.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor6.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor7.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor8.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor9.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor10.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor11.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor12.BackColor = Color.FromArgb(255, 255, 255);
    lblsensor13.ForeColor = Color.Green;
    lblsensor14.ForeColor = Color.Green;
    lblsensor15.ForeColor = Color.Green;
    lblsensor16.ForeColor = Color.Green;
    lblsensor17.ForeColor = Color.Green;
    lblsensor18.ForeColor = Color.Green;
    lblsensor19.ForeColor = Color.Green;
    drum = false;
}
else if(drum ==false)
{
    metroStyleManager1.Theme = MetroFramework.MetroThemeStyle.Dark
;
    zedGraphControl1.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
        zedGraphControl1.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
        zedGraphControl2.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
            zedGraphControl2.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
            zedGraphControl3.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
                zedGraphControl3.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
                zedGraphControl4.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
                    zedGraphControl4.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
                    zedGraphControl5.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
                        zedGraphControl5.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
                        zedGraphControl6.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));

```

```

zedGraphControl6.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl7.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl7.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl8.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl8.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl9.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl9.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl10.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl10.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl11.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl11.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl12.GraphPane.Fill = new Fill(Color.FromArgb(222, 224, 212));
zedGraphControl12.GraphPane.Chart.Fill = new Fill(Color.FromArgb(222, 224, 212));
lblsensor1.BackColor = Color.FromArgb(222, 224, 212);
lblsensor2.BackColor = Color.FromArgb(222, 224, 212);
lblsensor3.BackColor = Color.FromArgb(222, 224, 212);
lblsensor4.BackColor = Color.FromArgb(222, 224, 212);
lblsensor5.BackColor = Color.FromArgb(222, 224, 212);
lblsensor6.BackColor = Color.FromArgb(222, 224, 212);
lblsensor7.BackColor = Color.FromArgb(222, 224, 212);
lblsensor8.BackColor = Color.FromArgb(222, 224, 212);
lblsensor9.BackColor = Color.FromArgb(222, 224, 212);
lblsensor10.BackColor = Color.FromArgb(222, 224, 212);
lblsensor11.BackColor = Color.FromArgb(222, 224, 212);
lblsensor12.BackColor = Color.FromArgb(222, 224, 212);
lblsensor13.ForeColor = Color.White;
lblsensor14.ForeColor = Color.White;
lblsensor15.ForeColor = Color.White;
lblsensor16.ForeColor = Color.White;
lblsensor17.ForeColor = Color.White;
lblsensor18.ForeColor = Color.White;
lblsensor19.ForeColor = Color.White;
drum = true;
}
}

```



```

private void MetroTabPage1_Click(object sender, EventArgs e)
{
}

private void MetroTabPage2_Click(object sender, EventArgs e)
{
}

private void HtmlPanel1_Click(object sender, EventArgs e)
{
}

private void MetroLabel7_Click(object sender, EventArgs e)
{
}

private void CbDatabits_SelectedIndexChanged(object sender, EventArgs
e)
{
}

private void BtnConn_Click_1(object sender, EventArgs e)
{
    try
    {
        if (cbPorts.Text != "")
        {
            if (cbBaud.Text != "")
            {
                serialPort1.PortName = cbPorts.Text;
                serialPort1.BaudRate = Convert.ToInt32(cbBaud.Text);
                serialPort1.Parity = (Parity)Enum.Parse(typeof(Parity)
, cbParity.Text);
                serialPort1.StopBits = (StopBits)Enum.Parse(typeof(Stop
pBits), cbStopbits.Text);
                serialPort1.DataBits = Convert.ToInt32(cbDatabits.Text
);
                serialPort1.Handshake = Handshake.None;
                serialPort1.RtsEnable = true;
                serialPort1.DataReceived += new SerialDataReceivedEven
tHandler(serialPort1_DataReceived);
                if (serialPort1.IsOpen) return;
                serialPort1.Open();
                btnConn.Enabled = false;
            }
        }
    }
}

```



```

        btnDisConn.Enabled = true;
        //
        cbBaud.Enabled = false;
        cbPorts.Enabled = false;
        cbDatabits.Enabled = false;
        cbStopbits.Enabled = false;
        cbParity.Enabled = false;
        if (datalogger_checkbox.Checked)
            try { out_file.Dispose(); }
            catch {/*ignore*/}
        }
        else
            return;
    }
    else
        return;
}
catch
{
    return;
}
}

private void BtnDisConn_Click_1(object sender, EventArgs e)
{
    try
    {
        if (serialPort1.IsOpen == false) return;
        serialPort1.Close();
        btnConn.Enabled = true;
        btnDisConn.Enabled = false;
        //
        cbBaud.Enabled = true;
        cbPorts.Enabled = true;
        cbDatabits.Enabled = true;
        cbStopbits.Enabled = true;
        cbParity.Enabled = true;
    }
    catch
    {
        return;
    }
}

private void Datalogger_checkbox_CheckedChanged_1(object sender, EventArgs e)
{
    if (datalogger_checkbox.Checked)
    {

```



```
        if (openFileDialog1.ShowDialog() == DialogResult.OK)
        {
            datalogger_checkbox.Text = openFileDialog1.FileName;
            string text = "Time,H1,W1,H2,W2,H3,W3,H4,W4,H5,W5,H6,W6,T0
,T1,T2,T3,T4,T5,T6";
            System.IO.File.WriteAllText(@datalogger_checkbox.Text, tex
t);
        }
        else
        {
            datalogger_checkbox.Checked = false;
        }
    }
    else
    {
        datalogger_checkbox.Text = "Enable Data logger";
    }
}

private void Lbssensor3_Click(object sender, EventArgs e)
{
}

private void Timer16_Tick_1(object sender, EventArgs e)
{
    string[] ports = SerialPort.GetPortNames();
    if (intlen != ports.Length)
    {
        intlen = ports.Length;
        cbPorts.Items.Clear();
        for (int j = 0; j < intlen; j++)
        {
            cbPorts.Items.Add(ports[j]);
        }
    }
}
```



## 14.Device

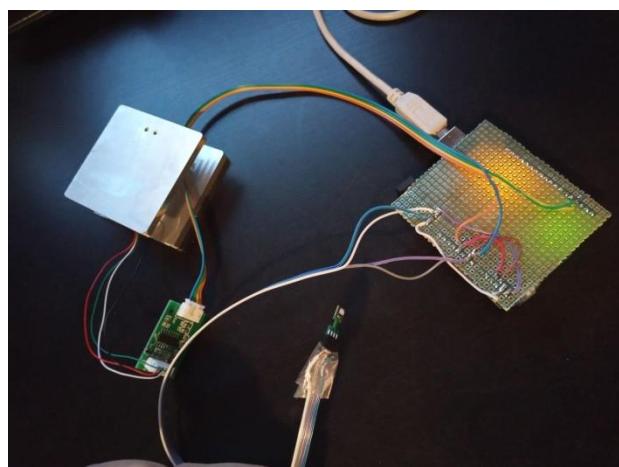
### 14.1 First Prototype

The picture below is representing the first prototype. It is consisting of one chip HX711, one bread board, SHT85 temperature/humidity sensor, arduino, load cell, cup, rings and metal plates. The first prototype was with so many cables and was really unstable with so many errors. But the main aim of it was to prove that the research beforehand is right and accurate. Also to check if this setup is good for next step of prototyping.



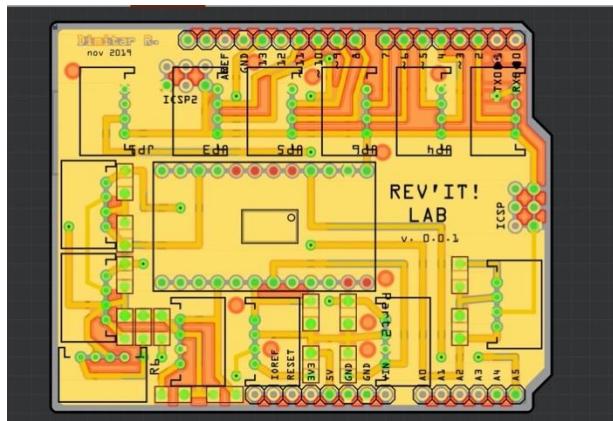
### 14.2 Second Prototype

Next developing step was the second prototype. The second prototype is consisting of same components as the first one but this time there is not that many bugs and errors. Also there is no that many cables. The sensors started to be plug and play. Also everything began to be easy replaceable. The second prototype is visible in the picture below.

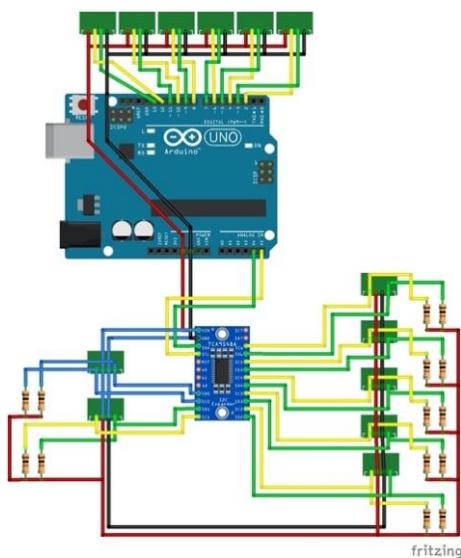


### 14.3 Final Prototype / Final Device

The figure below is representing the PCB (Printed circuit board) of the final prototype. This is a pseudo representation of it. In real the PCB won't look like that. The PCB is containing only female 4 pin connector for all of the sensors and everything will be really easily to be disconnected or connected. In center there is socket for the I2C extender.



The figure below is representing a pseudo schematic of the final prototype. The schematic is prepared especially for non-engineering people and is representing all of the components and connection in really easy and accessible way. The top part of it they are six HX711 chips that are connected to 500g load cells bridges. In the bottom of the schematic there are seven SHT85 temperature/humidity sensors. Six of them are for the six cups and one for measuring the environment of the oven. They are connected directly to I2C extender which is connected to the microcontroller.



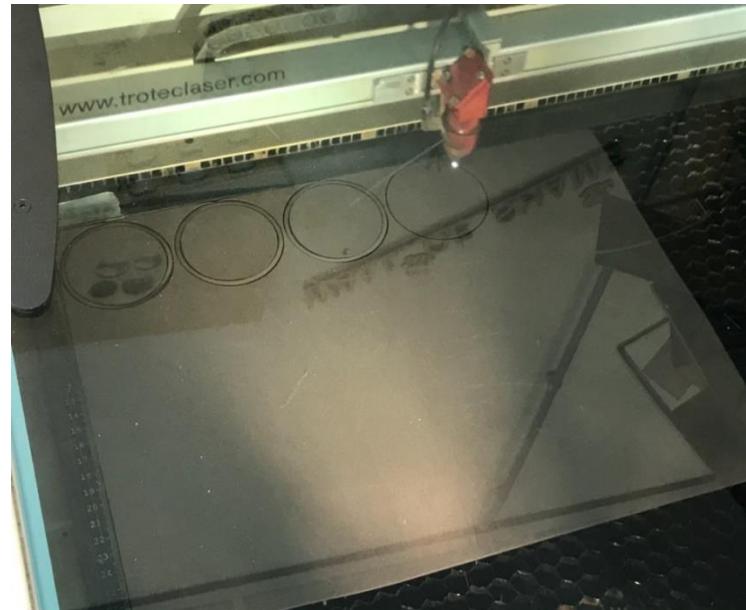
The final product consist from 6 packs of cup, SHT85 (temperature/humidity sensors), 2 x foam rings, 1 x plastic rings and also a metal plate that has on it one motherboard with 6 chips and 6 load cells that are measuring the weight of the cups. Everything is with hotspot connection and really easy changeable.



## 15. Laser

Because of the circumstances that one of our team members (Harold Kip) supposed to leave our team, we should finish his part of the work. His role was mainly mechanical, for example replicating the cups, drilling wholes, gluing cables and laser cutting. Anything related with his speciality. Because of this we supposed to laser cut the foam and plastic rings for the cups. None of the team members did not know how to work with the laser. But we asked first in FabLab with unfortunately we did not have the materials. That was the first problem.

We supposed to find from somewhere foam and plastic material. In the end we find the materials in the Product Design department and also we asked them for help for laser cutting. We figure out that they have laser cutter. Because of the Product Design department and all of the nice people there we were able to have this result. They gave us the material and also help us to laser cut the rings. The whole process is visible in the picture around the text.



## 16.Interview

Smart Solution Semester - Interview

Dimitar Rangelov <445392@student.saxion.nl>

Mon 12/16/2019 1:46 PM

To: Ümit Guler <u.guler@saxion.nl>

Hello Mr. Guler,

As I informed you we need to take technical interview from you for our Smart Solution Semester.  
Also I explained you in person what is the project that we are developing.

The questions are following:

1. What is the best temperature/humidity sensor for professional purposes and with good accuracy?
2. Is it acceptable to use Arduino Uno for the prototype of our product in your opinion?
3. What kind of connection we should make between the controller and the sensors to be easier for maintaining?

That are all of my questions that are covering all of the topics in the project.

Thanks in advance for your answers.

Best regards,  
Dimitar

Mon 12/16/2019 2:15 PM

To: Dimitar Rangelov <445392@student.saxion.nl>

Hello Dimitar,

Yes we had a discussion about the project before.

And these are my answers:

- 1.I recommend for more professional usages of temperature/humidity sensors to go to the SHTxx family. For your project you can use for example SHT31 or SHT85. They will perfectly fit in the conditions that you have and with high accuracy.
- 2.For prototype is acceptable to use Arduino UNO as a board but furthermore it is preferable to make your own board with ATMEGA328 or to use other chips.
- 3.It is good to use hot spot connection with connector. In that case if something is burned you can easily change it. Don't make it with solid connections.

If there is something else that I can help you just come by my office.

Best regards,  
Umit Guler



## 17. Midterm presentation



## CONTENT

1. Introduction
2. The prototype
3. Demonstration
4. Next steps
5. Questions

SMART SOLUTIONS SEMESTER

2

## INTRODUCTION

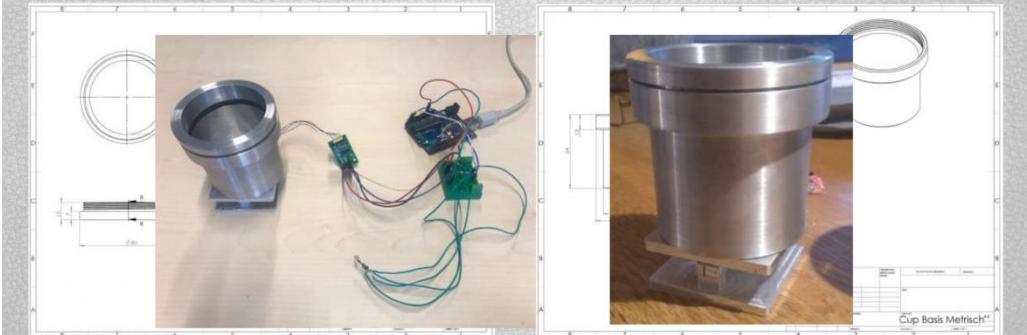
- REV'IT!
- Ensuring comfort and safety
- Create a testing device which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity.

SMART SOLUTIONS SEMESTER

3



## THE PROTOTYPE



SMART SOLUTIONS SEMESTER

4



## THE PROTOTYPE

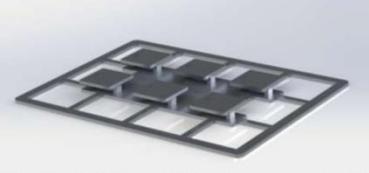


SMART SOLUTIONS SEMESTER

5



## THE PROTOTYPE



SMART SOLUTIONS SEMESTER

6



## DEMONSTRATION

## NEXT STEPS

1. Creating a tray of aluminium
2. Testing the device
3. Testing fabrics inside the oven
4. Evaluate the results

SMART SOLUTIONS SEMESTER

8



## QUESTIONS?



## 18.Last Presentation REVIT

1/21/2020

Mail - Dimitar Rangelov - Outlook

### RE: Invitation presentation

Jorrit Memel <JMemel@revit.eu>

Mon 1/20/2020 4:34 PM

To: Femke Visser <435542@student.saxion.nl>; Jasper den Dekker <JdenDekker@revit.eu>  
 Cc: Jenny Hesse <j.hesse@saxon.nl>; Dimitar Rangelov <445392@student.saxion.nl>; Le Van Hoang Minh Lê <467475@student.saxion.nl>; Isabel Wesselink <434129@student.saxion.nl>

Hi all,

Great! We will see you this coming Thursday. I like your confidence but be prepared that we will have tons of questions for you. They "only" thing you have to do is knock our socks off.

Best,

**Jorrit Memel**  
 Lab Coordinator



REVIT! Sport International B.V.

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The Netherlands

T +31 412 696 751

F +31 412 696 750

[jmemel@revit.eu](mailto:jmemel@revit.eu)

[www.revitsport.com](http://www.revitsport.com)

Take a look at the REV'IT! digital REVzine

Follow us on

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Please consider the environment before printing this e-mail

**From:** Femke Visser [mailto:[435542@student.saxion.nl](mailto:435542@student.saxion.nl)]

**Sent:** maandag 20 januari 2020 15:53

**To:** Jorrit Memel

**Cc:** Jenny Hesse; Dimitar Rangelov; Le Van Hoang Minh Lê; Isabel Wesselink

**Subject:** Re: Invitation presentation

Hi Jorrit,

We have arranged a car so it is possible for us to meet at REV'IT! Thursday 23rd of January at 10:30!  
 We actually think the presentation will not take an hour and a half but more around 30/40 minutes including questions.

See you then!

Kind regards,  
 Femke Visser

<https://outlook.office.com/mail/inbox/id/AAQkADYwNDkyMGZiLWU4MTQtNDcwMS1iZDRkLWU3N2QzMzdIZjlxZgAQAL181IAFhrROtkqrRnNOy8...> 1/4



## SMART SOLUTIONS SEMESTER

Testing device membrane fabrics for motorcycling



## CONTENT

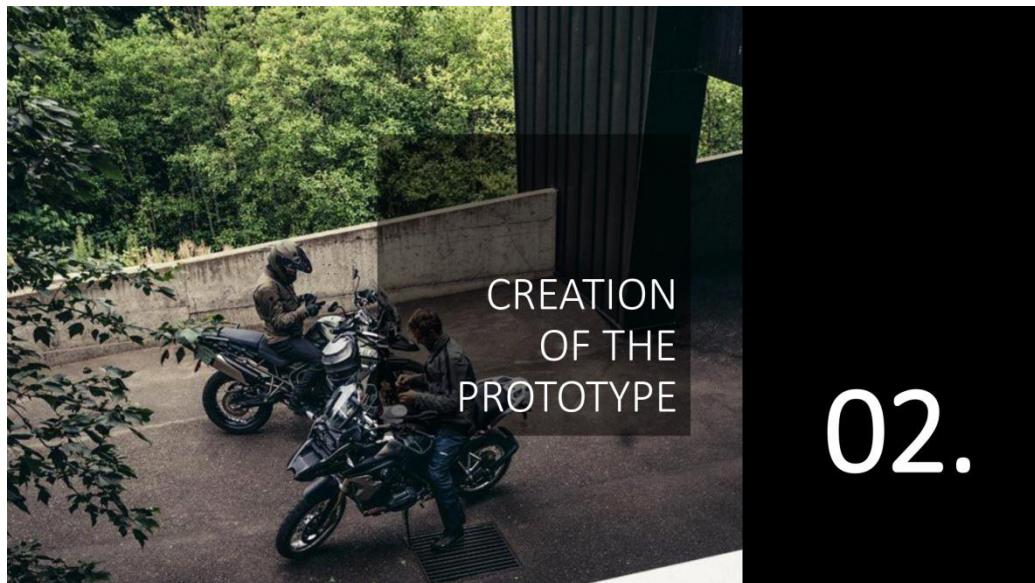
- Introduction
- Creation of the prototype
- Testing
- Results
- Manual
- Questions



01.



- REV'IT!
- Saxion University of Applied Science Enschede
- Electrical Engineering and Fashion & Textile Technologies
- Comfort and safety
- Create a testing device which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity



## RECREATION



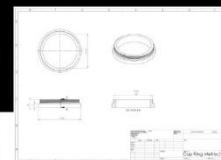
**Recreated rings**

Laser cut foam and paper rings



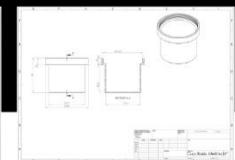
**Recreated cup**

Aluminium cup



**Technical drawing cup ring**

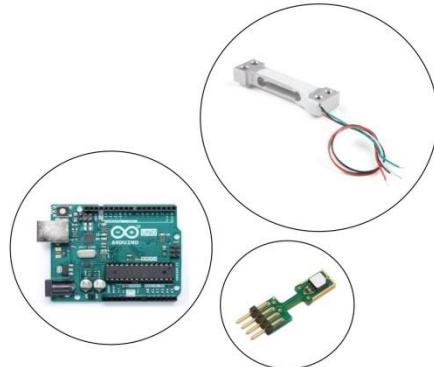
Recreated aluminium cup ring



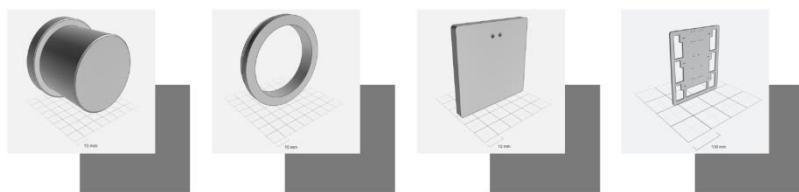
**Technical drawing cup**

Recreated aluminium cup



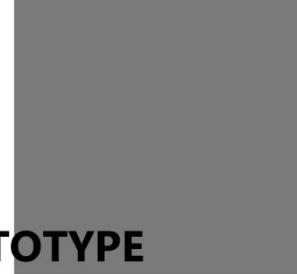


7



## EXPECTED VIEW PROTOTYPE

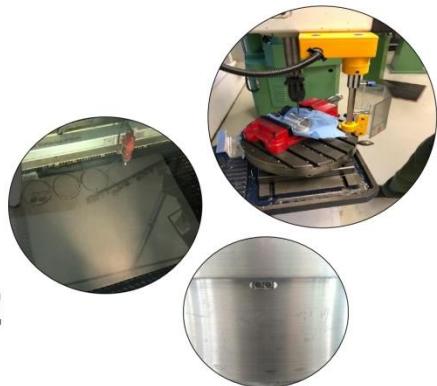




PROTOTYPE



MANUFACTURE



## HERAEUS B 5028

230 V  
50-60 Hz  
0.29 kW  
30 liters  
100 C - 700 C  
Built-in thermometer  
Smooth regulation  
29 kgs  
Inside: 28 x 33 x 35 cm

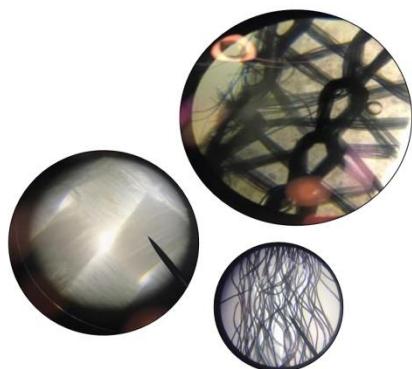
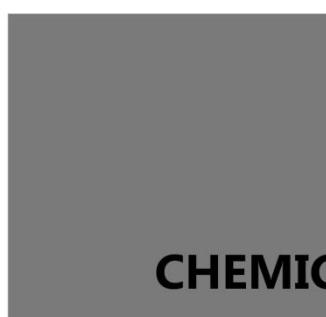


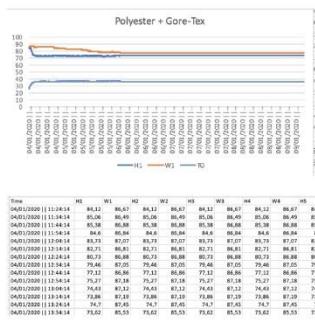


## SOFTWARE

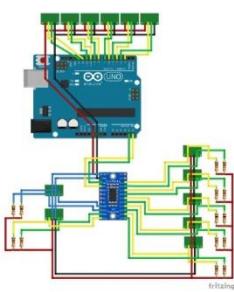
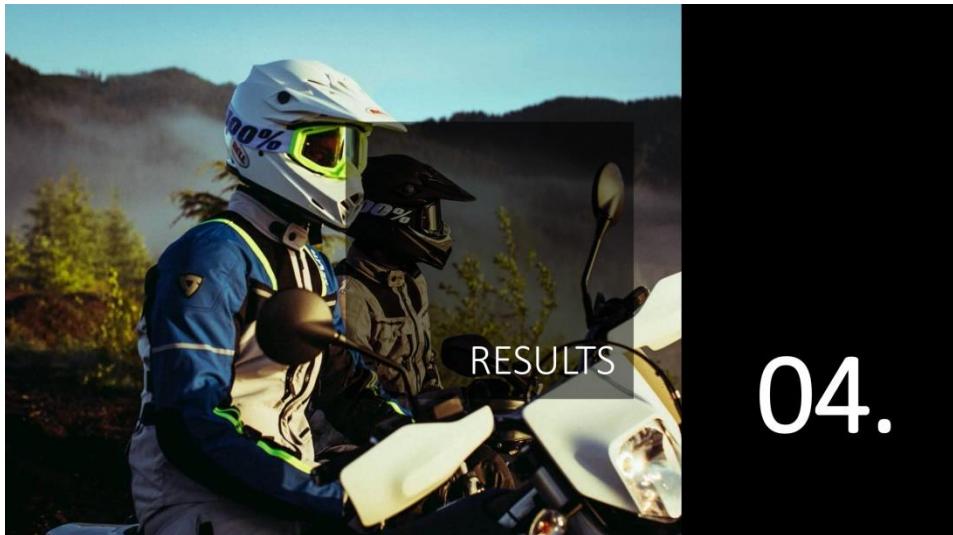


03.





## TESTING PROTOTYPE



## FINAL PROTOTYPE

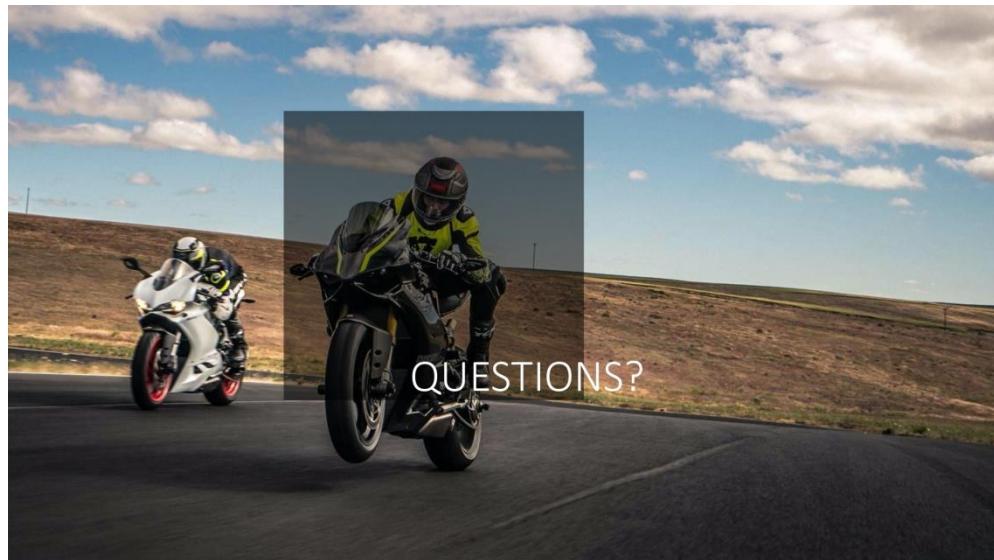




05.



STEP-B

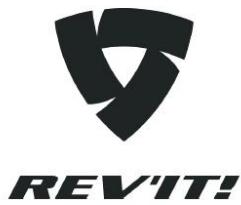


The picture below is from the final presentation of the project in the REVI'Ts Labs. We present the presentation in the pictures above and after that we demonstrate the final prototype. Our team provided the user manual to Jorrit from REVI'T and explained each of the steps.



## 19. Product Manual

# BREATHABILITY TEST MANUAL



# BREATHABILITY TEST

## MANUAL

Femke Visser  
Isabel Wesselink  
Dimitar Rangelov  
Le Van Hoang Minh

January 2020

Saxion University of Applied Science



## INTRODUCTION

This manual contains a complete description of the steps which needs to be taken to perform the Breathability test of REV'IT! This test has been adjusted by Saxion students of the Electrical Engineering and the Fashion & Textile Technologies department to make the test results more accurate. These changes were translated into a prototype which was developed during the Smart Solutions Semester project at Saxion Enschede.

The following device has been developed:

A device which can determine the breathability of a fabric by measuring the weight of the cups, the temperature and the humidity at all times during the test. These measurements are tasks during the test and displayed in a graph. With this data REV'IT! can determine how long it takes for a fabric to breathe.

We hope REV'IT! can use the created device well and that it shows the desired results to give their customers the guarantee of breathable materials.

January 2020,  
Enschede



## STEP BY STEP INSTRUCTIONS

The following pictures explain how to perform the Breathability test.



1. First power needs to be provided for the Heraeus incubator. Also check the control board on the left side of the incubator.



2. Open the glass protection and places the iron tray inside the incubator. Make sure the tray is placed in the middle of the incubator.



3. Turn on the switch button to start the incubator.



4. Check the thermometer on the top left of the incubator to see the actual temperature inside the incubator.



5. Adjust the knot at the bottom-left of the oven to set the temperature limit inside the incubator.





6. When the limit temperature has been chosen, rotate the knot below the thermometer to set an temperature for the experiment. Notice that the temperature will be limited by the temperature limit set in step 5.



7. The temperature inside the incubator will slowly rise. Use the button bewllow the green light to set a time if necessary (up to 24 hours). Switch the button to EIN mode, after the experiment is finished, the green light will light up.



8. Finally, place the tray as described in the following steps, in the incubator. Close the glass protection door and start the experiment.



9. Connect all of the load cells to the tray.



10. Put all six cups on the upper plates.



11. Connect all of the SHT85 sensors to all six cups. \*All the sensors MUST be connected in this phase otherwise the sensors will not initialize afterwards.

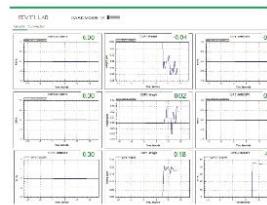




12. Place the tray without the six cups inside the incubator. Connect the device, using the JSAux USB Printer Scanner Cord, to a laptop or PC. The cable goes through the hole on top of the incubator to the laptop or PC.



13. Open REV'IT! software and click on 'Connection'. Choose your port and put the same settings as the picture on the left.



14. Click on 'Graphs'.



15. Take out the ring of the cups.



16. Fill the cups with water just below the temperature and humidity sensor.



17. Put the first foam ring in the cups.





18. Put the fabric and or membrane in the cups.



19. Put the second foam ring in the cups.



20. Put the plastics ring in the cups.



21. Put the ring back on the cups.



22. Place the six cups on the right upper plates (step 8) .Check 'Graphs' within the software.  
\*Notice: For the picture only cup 6 was used.



23. Open 'Connection'.





24. Click on 'Enable data logger'.



25. A window will pop up.



26. Create a new 'text file'. Select it and click 'Open'.



27. The name of your log file will appear on the screen. This means that logging of the data is started. The file saves automatically.

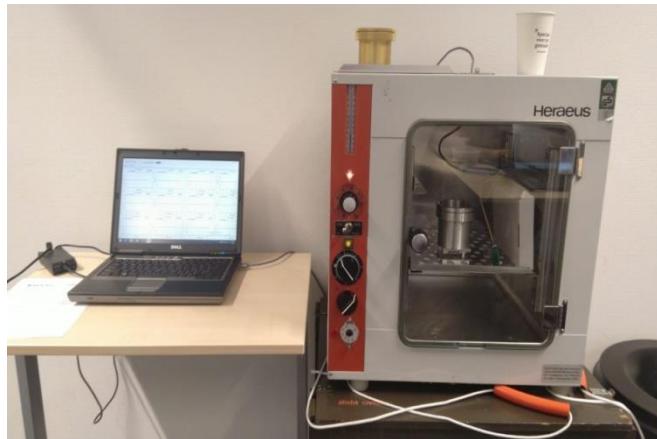
After following the steps an Excel file can be created. This file provides an overview including the date of the test, the measured time, the weight of the cups ( $W_1$  = Weight cup 1), the humidity inside the cups ( $H_1$  = Humidity cup 1), the temperature of the incubator ( $T_0$ ) and the temperature of the cups ( $T_1$  = Temperature cup 1). This file can then be converted into a graph for a better overview.

When the test is finished disconnect the incubator with the laptop or PC. Then remove the tray with the six cups from the incubator and turn the incubator off.



## 20. Testing

The picture below is representing the first testing/experiment setup that was located in one of the working smart solution rooms in Saxion.



We work together on every of the first experiments. Also we analyze and discuss each of the experiments.



The pictures below are representing the final prototype setup that was located in my place. And the first test that was indicating that the final device is working properly.



The picture below is from the last experiment. For more information about it is visible at [Testing final prototype – REV'IT! & Intrepid \(21/01/2020 – 22/01/2020\)](#).



There are more pictures below from the last experiment that is proving that the final prototype is able to work with 6 cups for first time. Also in the right picture is visible my help to the experiment.



## 20.1 Testing final prototype – REV'IT! & Intrepid (21/01/2020 – 22/01/2020)

Time	H1	W1	H2	W2	H3	W3	H4	W4	H5	W5	H6
21/01/2020    12:44:34	78.25	105.5	80.86	100.43	78.74	101.4	85.74	117.75	86.88	105.29	84.34
21/01/2020    12:54:34	79.37	105.5	82.54	100.4	80.29	101.36	86.63	117.45	87.78	105.37	85.38
21/01/2020    13:04:34	80.48	105.6	83.81	100.42	80.8	101.41	87.36	117.35	88.46	105.42	86.28
21/01/2020    13:14:34	80.6	105.7	84.82	100.43	82.11	101.49	87.84	117.27	89.1	105.46	87.09
21/01/2020    13:24:34	82.04	105.8	85.86	100.42	82.18	101.53	88.08	117.25	89.57	105.53	87.62
21/01/2020    13:34:34	83.15	106	86.36	100.4	82.83	101.66	88.29	117.25	90.01	105.59	88.05
21/01/2020    13:44:34	84.25	106.1	86.32	100.39	85.88	101.77	88.68	117.23	90.35	105.58	88.36
21/01/2020    13:54:34	83.88	106.3	85.93	100.36	86.38	101.88	89.03	117.26	90.7	105.59	88.54
21/01/2020    14:04:34	83.62	106.4	85.68	100.27	86.33	101.92	89.25	117.17	90.72	105.71	88.53
21/01/2020    14:14:34	83.81	106.5	85.38	100.24	85.84	102.09	89.6	117.18	91.24	105.77	89.16
21/01/2020    14:24:34	84.74	106.6	85.34	-202.77	86.33	102.26	89.74	117.23	91.5	105.79	89.63
21/01/2020    14:34:34	85.18	106.7	85.89	100.21	86.9	102.42	90.14	117.32	91.84	105.81	89.79
21/01/2020    14:44:34	85.69	106.9	86.24	100.22	86.98	102.58	90.39	117.39	92.11	105.81	90.08
21/01/2020    14:54:34	86.23	107	86.81	100.18	87.41	102.73	90.68	117.48	92.42	105.82	90.33
21/01/2020    15:04:34	86.73	107.1	87.31	100.15	88.28	102.86	90.94	117.57	92.57	105.87	90.56
21/01/2020    15:14:34	86.91	107.1	87.38	100.08	88.24	102.98	91.06	117.64	92.8	105.87	90.71
21/01/2020    15:24:34	87.04	107.1	88	100.04	88.81	103.08	91.35	117.7	92.9	105.91	90.95
21/01/2020    15:34:34	87.49	107.2	88.32	100.02	88.76	103.2	91.48	117.78	93.04	105.93	91.08
21/01/2020    15:44:34	87.76	107.2	88.44	99.99	89.09	103.27	91.54	117.85	93.13	105.95	91.32
21/01/2020    15:54:34	87.75	107.2	88.65	99.93	89.41	103.37	91.8	117.94	93.22	105.99	91.33
21/01/2020    16:04:34	87.74	107.2	88.63	99.87	89.8	103.45	91.98	118.02	93.54	105.99	91.52
21/01/2020    16:14:34	88.12	107.2	88.96	99.86	89.46	103.5	91.96	118.08	93.5	106.01	91.6
21/01/2020    16:24:34	88.35	107.1	88.97	99.81	89.62	103.57	92.03	118.15	93.51	106.05	91.62
21/01/2020    16:34:34	88.63	107.1	89.13	99.79	89.74	103.62	92.09	118.25	93.6	106.06	91.82
21/01/2020    16:44:34	88.67	107.1	89.18	99.74	90.27	103.67	92.26	118.32	93.72	106.09	91.98
21/01/2020    16:54:34	88.81	107.1	89.41	99.73	90.5	103.72	92.36	118.39	93.7	106.12	92.01
21/01/2020    17:04:34	89	107.1	89.51	99.72	90.47	103.76	92.33	118.43	93.86	106.14	92.09
21/01/2020    17:14:34	89.16	107	89.55	99.69	90.42	103.8	92.39	118.51	93.95	106.17	92.09

21/01/2020    17:24:34	89.31	107	89.6	99.67	90.57	103.85	92.6	118.67	93.88	106.15	92.3
21/01/2020    17:34:34	89.16	107	89.72	99.64	90.79	103.88	92.65	118.75	94.01	106.15	92.24
21/01/2020    17:44:34	89.37	106.9	89.81	99.63	90.81	103.91	92.66	118.82	94.09	106.17	92.39
21/01/2020    17:54:34	89.37	106.9	89.81	99.6	90.65	103.95	92.69	118.86	94.07	106.19	92.41
21/01/2020    18:04:34	89.34	106.9	89.77	99.56	90.85	103.97	92.75	118.9	94.21	106.21	92.45
21/01/2020    18:14:34	89.27	106.9	89.85	99.62	90.84	104.08	92.79	119.07	94.23	106.33	92.47
21/01/2020    18:24:34	89.44	106.8	89.85	99.52	90.86	103.94	92.85	118.99	94.04	106.3	92.64
21/01/2020    18:34:34	89.46	106.7	89.83	99.49	90.71	103.97	92.87	119.03	94.11	106.28	92.6
21/01/2020    18:44:34	89.52	106.7	89.94	99.44	91.02	103.97	93.06	119.09	94.26	106.34	92.58
21/01/2020    18:54:34	89.65	106.7	90.06	99.44	91.16	103.99	92.9	118.91	94.11	106.54	92.64
21/01/2020    19:04:34	89.7	106.7	90.42	99.46	91.38	104.08	93.1	118.98	94.51	106.54	92.82
21/01/2020    19:14:34	90.4	106.7	91.02	99.47	91.61	104.19	93.15	119.06	94.53	106.55	92.96
21/01/2020    19:24:34	90.64	106.8	90.9	99.48	91.96	104.19	93.18	119.09	94.44	106.55	92.96
21/01/2020    19:34:34	90.57	106.7	90.78	99.44	91.94	104.18	93.27	119.14	94.53	106.57	92.94
21/01/2020    19:44:34	90.29	106.7	90.96	99.42	91.82	104.25	93.33	119.19	94.81	106.56	93.06
21/01/2020    19:54:34	90.2	106.7	91.13	99.45	92.31	104.32	93.55	119.23	94.69	106.56	93.04
21/01/2020    20:04:34	90.49	106.6	90.72	99.43	91.96	104.37	93.41	119.22	94.91	106.57	93.29
21/01/2020    20:14:34	90.18	106.6	90.34	99.36	92.35	104.35	93.45	119.23	94.83	106.57	93.21
21/01/2020    20:24:34	90.28	106.5	90.28	99.34	92.63	104.29	93.43	119.21	94.78	106.57	93.23
21/01/2020    20:34:34	89.98	106.4	90.15	99.29	92.27	104.24	93.58	119.19	94.78	106.57	93.31
21/01/2020    20:44:34	90.22	106.3	90.15	99.27	91.73	104.16	93.59	119.15	94.59	106.57	93.12
21/01/2020    20:54:34	89.87	106.3	90.33	99.26	91.75	104.11	93.63	119.12	94.49	106.56	92.97
21/01/2020    21:04:34	89.42	106.2	90.58	99.24	91.82	104.02	93.52	119.09	94.4	106.58	92.83
21/01/2020    21:14:34	88.96	106.1	90.64	99.25	91.93	103.95	93.45	119.05	94.38	106.57	92.66
21/01/2020    21:24:34	88.72	106	90.77	99.25	91.78	103.9	93.42	118.99	94.25	106.59	92.52
21/01/2020    21:34:34	88.61	105.9	90.79	99.26	91.65	103.77	93.27	118.94	94.14	106.55	92.37
21/01/2020    21:44:34	88.32	105.8	90.81	99.26	91.57	103.72	93.14	118.88	94.02	106.58	92.26
21/01/2020    21:54:34	88.1	105.7	90.74	99.24	91.54	103.66	93.06	118.82	93.92	106.58	92.18
21/01/2020    22:04:34	87.87	105.7	90.64	99.24	91.48	103.58	92.99	118.77	93.86	106.57	92.18
21/01/2020    22:14:34	87.82	105.6	90.66	99.26	91.48	103.53	92.97	118.72	93.82	106.58	92.17
21/01/2020    22:24:34	87.82	105.6	90.77	99.28	91.44	103.46	92.92	118.65	93.84	106.58	92.16

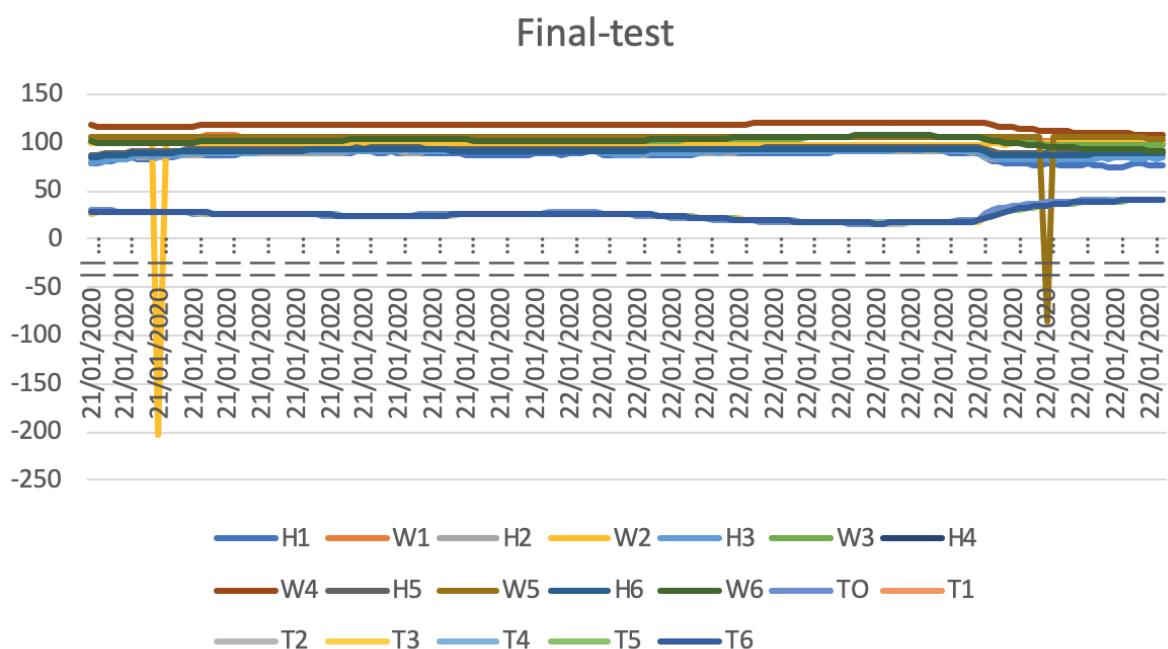
21/01/2020    22:34:34	87.66	105.5	90.58	99.29	91.37	103.38	92.87	118.59	93.82	106.58	92.16
21/01/2020    22:44:34	87.65	105.4	90.68	99.3	91.33	103.31	92.84	118.55	93.82	106.56	92.11
21/01/2020    22:54:34	87.72	105.4	90.68	99.3	91.32	103.28	92.83	118.47	93.74	106.58	92.12
21/01/2020    23:04:34	87.77	105.4	90.78	99.31	91.36	103.22	92.8	118.41	93.75	106.56	92.09
21/01/2020    23:14:34	87.95	105.4	90.9	99.35	91.38	103.2	92.87	118.33	93.76	106.55	92.1
21/01/2020    23:24:34	88.09	105.4	91.08	99.34	91.33	103.14	92.91	118.29	93.8	106.56	92.15
21/01/2020    23:34:34	88.25	105.3	91.2	99.35	91.26	103.15	92.91	118.22	93.81	106.55	92.16
21/01/2020    23:44:34	88.22	105.4	91.27	99.39	91.35	103.13	92.97	118.16	93.92	106.55	92.21
21/01/2020    23:54:34	88.36	105.3	91.35	99.4	91.33	103.11	92.97	118.09	93.93	106.52	92.2
22/01/2020    00:04:34	88.34	105.3	91.41	99.38	91.42	103.09	93.02	118.07	93.97	106.53	92.24
22/01/2020    00:14:34	88.21	105.3	91.39	99.4	91.58	103.09	93.07	118.01	94.02	106.51	92.3
22/01/2020    00:24:34	88.42	105.3	91.49	99.4	91.51	103.08	93.08	117.96	94	106.51	92.32
22/01/2020    00:34:34	88.45	105.3	91.52	99.41	91.35	103.08	93.05	117.9	94.06	106.5	92.28
22/01/2020    00:44:34	88.36	105.3	91.43	99.4	91.89	103.08	93.16	117.86	94.27	106.49	92.3
22/01/2020    00:54:34	91.06	105.4	91.55	99.39	92.09	103.11	92.95	117.8	94.28	106.48	92.18
22/01/2020    01:04:34	90.88	105.2	91.43	99.33	91.13	102.95	92.88	117.8	93.85	106.48	92.14
22/01/2020    01:14:34	87.95	104.9	89.88	99.18	90.29	102.67	92.72	117.72	93.74	106.46	92.07
22/01/2020    01:24:34	86.93	104.7	90.05	99.12	89.38	102.5	92.53	117.71	93.59	106.47	92.01
22/01/2020    01:34:34	86.34	104.6	88.28	99.03	87.7	102.36	92.6	117.71	93.7	106.46	92
22/01/2020    01:44:34	86.54	104.5	87.94	99.01	87.82	102.3	92.63	117.75	93.55	106.45	91.92
22/01/2020    01:54:34	86.75	104.4	87.9	98.97	87.46	102.27	92.69	117.78	93.77	106.44	92.17
22/01/2020    02:04:34	86.84	104.3	87.85	98.98	88.17	102.27	92.82	117.86	93.66	106.46	92.36
22/01/2020    02:14:34	86.95	104.3	88	98.96	88.48	102.33	92.94	117.92	93.89	106.43	92.29
22/01/2020    02:24:34	87	104.4	88.3	98.96	88.51	102.37	92.84	118.01	93.84	106.43	92.45
22/01/2020    02:34:34	87.14	104.4	88.74	98.95	88.98	102.48	92.88	118.13	94.02	106.43	92.49
22/01/2020    02:44:34	87.64	104.5	89.03	98.93	88.92	102.59	92.94	118.23	94.09	106.38	92.57
22/01/2020    02:54:34	87.66	104.6	89.07	98.88	89.73	102.73	93.08	118.33	94.12	106.37	92.69
22/01/2020    03:04:34	87.91	104.6	89.25	98.89	89.95	102.85	93.09	118.44	94.08	106.36	92.92
22/01/2020    03:14:34	88	104.7	89.65	98.84	90.2	102.99	93.15	118.55	94.2	106.32	92.71
22/01/2020    03:24:34	88.21	104.8	89.6	98.78	89.66	103.1	93.37	118.68	94.26	106.29	92.92
22/01/2020    03:34:34	88.3	104.8	89.74	98.71	90.17	103.26	93.05	118.79	94.25	106.27	92.96

22/01/2020    03:44:34	88.66	104.9	89.81	98.7	90.61	103.38	93.17	118.92	94.26	106.25	93.07
22/01/2020    03:54:34	88.71	105	90.1	98.66	90.59	103.53	93.18	119.06	94.29	106.24	92.97
22/01/2020    04:04:34	88.79	105.1	89.97	98.62	89.75	103.66	93.58	119.16	94.32	106.2	93
22/01/2020    04:14:34	89	105.1	90.2	98.56	91.15	103.8	93.19	119.29	94.34	106.19	93.17
22/01/2020    04:24:34	89.09	105.1	90.25	98.52	90.47	103.88	93.54	119.4	94.45	106.16	92.95
22/01/2020    04:34:34	89.04	105.2	90.41	98.43	90.75	104.04	93.32	119.54	94.47	106.15	93.11
22/01/2020    04:44:34	89.15	105.2	90.41	98.4	91.16	104.15	93.24	119.66	94.38	106.15	93.06
22/01/2020    04:54:34	89.24	105.3	90.62	98.37	91.04	104.28	93.3	119.78	94.48	106.11	93.12
22/01/2020    05:04:34	89.46	105.4	90.47	98.34	91.29	104.4	93.44	119.88	94.49	106.11	93.19
22/01/2020    05:14:34	89.64	105.4	90.69	98.28	90.74	104.52	93.52	119.98	94.65	106.11	93.27
22/01/2020    05:24:34	89.67	105.5	90.62	98.28	90.88	104.66	93.56	120.1	94.54	106.08	93.28
22/01/2020    05:34:34	89.78	105.5	90.69	98.22	90.83	104.74	93.44	120.19	94.68	106.07	93.29
22/01/2020    05:44:34	89.79	105.5	90.78	98.2	91.09	104.81	93.5	120.29	94.8	106.07	93.28
22/01/2020    05:54:34	89.9	105.6	90.91	98.17	91.11	104.91	93.6	120.39	94.81	106.07	93.31
22/01/2020    06:04:34	89.89	105.6	90.84	98.13	91.24	105	93.46	120.47	94.71	106.07	93.25
22/01/2020    06:14:34	90.08	105.6	90.86	98.06	91.02	105.06	93.54	120.56	94.78	106.07	93.34
22/01/2020    06:24:34	90.12	105.6	91.02	98.02	91.49	105.15	93.46	120.63	94.75	106.07	93.35
22/01/2020    06:34:34	90.22	105.7	90.94	98.01	91.32	105.24	93.77	120.71	94.9	106.07	93.44
22/01/2020    06:44:34	90.21	105.7	91.09	97.97	91.44	105.29	93.61	120.8	94.97	106.07	93.39
22/01/2020    06:54:34	90.44	105.7	91.12	97.97	91.49	105.35	93.55	120.86	95	106.06	93.53
22/01/2020    07:04:34	90.35	105.8	91.21	97.93	91.58	105.43	93.61	120.94	95	106.07	93.41
22/01/2020    07:14:34	90.45	105.8	91.14	97.89	91.8	105.47	93.75	121.03	95.1	106.07	93.45
22/01/2020    07:24:34	90.65	105.8	91.25	97.89	91.83	105.52	93.67	121.1	95.08	106.07	93.56
22/01/2020    07:34:34	90.65	105.8	91.32	97.84	91.77	105.56	93.78	121.15	95.21	106.09	93.52
22/01/2020    07:44:34	90.66	105.8	91.26	97.8	91.86	105.61	93.64	121.23	95.19	106.06	93.45
22/01/2020    07:54:34	90.69	105.8	91.36	97.77	92.06	105.54	93.82	121.25	95.1	106.14	93.54
22/01/2020    08:04:34	90.53	105.8	91.89	97.77	91.98	105.64	94.09	121.31	95.23	106.14	93.79
22/01/2020    08:14:34	91.05	105.9	91.26	97.8	92.25	105.74	94.08	121.34	95.73	106.14	94.18
22/01/2020    08:24:34	90.49	105.9	91.04	97.79	92.67	105.82	94.14	121.34	95.94	106.17	94.15
22/01/2020    08:34:34	91	105.9	91.28	97.79	92.68	105.85	94.21	121.32	95.82	106.15	94.04
22/01/2020    08:44:34	91.32	105.9	91.63	97.78	92.92	105.83	94.35	121.32	95.86	106.15	93.96

22/01/2020    08:54:34	91.41	105.9	91.4	97.77	92.26	105.79	94.36	121.27	95.75	106.14	93.89
22/01/2020    09:04:34	91.05	105.8	91.76	97.78	92.59	105.77	94.38	121.24	95.75	106.16	93.77
22/01/2020    09:14:34	90.89	105.8	91.54	97.76	92.71	105.73	94.26	121.16	95.43	106.16	93.46
22/01/2020    09:24:34	90.55	105.8	91.41	97.75	92.56	105.67	94.24	121.1	95.36	106.15	93.46
22/01/2020    09:34:34	90.33	105.7	91.12	97.76	92.33	105.6	94.21	121.08	95.34	106.16	93.41
22/01/2020    09:44:34	90.28	105.6	90.88	97.75	92.06	105.54	94.13	120.95	95.29	106.18	93.28
22/01/2020    09:54:34	90.19	105.5	90.62	97.75	91.75	105.45	94.01	120.89	95.16	106.17	93.15
22/01/2020    10:04:34	90.17	105.5	90.36	97.76	91.61	105.35	93.89	120.81	95.05	106.19	93.03
22/01/2020    10:14:34	90.07	105.4	90.27	97.81	91.42	105.26	93.7	120.71	94.83	106.19	92.83
22/01/2020    10:24:34	89.94	105.3	90.48	97.8	91.41	105.17	93.75	120.62	94.71	106.21	92.79
22/01/2020    10:34:34	85.31	105.5	85.36	98.29	87.27	104.94	93.05	119.78	93.71	106.1	91.15
22/01/2020    10:44:34	81.55	105.2	83.1	98.77	84.32	104.47	90.29	118.59	90.9	105.82	88.01
22/01/2020    10:54:34	80.77	104.5	82.88	98.76	83.57	103.45	89	117.52	89.92	105.84	86.91
22/01/2020    11:04:34	79.35	103.7	81.99	98.69	82.8	102.42	88.92	116.56	89.75	105.93	86.87
22/01/2020    11:14:34	78.37	103	82.14	98.9	82.35	101.5	88.7	115.76	89.36	105.98	86.58
22/01/2020    11:24:34	79.52	102.5	82.87	99.03	82.58	100.68	88.83	115.01	89.58	106.12	86.7
22/01/2020    11:34:34	79.14	102.1	83.52	99.2	82.96	100.04	89.03	114.37	89.72	106.18	87.1
22/01/2020    11:44:34	77.23	101.8	82.76	99.37	82.13	99.49	89.03	113.77	89.65	106.21	86.99
22/01/2020    11:54:34	77.32	101.7	84.07	99.56	82.36	99.06	88.98	113.22	89.57	106.22	86.89
22/01/2020    12:04:34	77.72	101.5	84.94	99.71	82.96	98.7	88.97	112.74	89.47	-84.68	86.93
22/01/2020    12:14:34	78.39	101.5	85.75	99.77	81.55	98.41	88.88	112.3	89.39	106.17	86.93
22/01/2020    12:24:34	77.47	101.5	86.33	99.81	83.16	98.19	89.05	111.91	89.45	106.11	87.29
22/01/2020    12:34:34	75.76	101.5	84.86	99.83	82.85	97.99	88.84	111.51	89.49	106.04	87.4
22/01/2020    12:44:34	75.85	101.5	86.29	99.84	83.13	97.83	89.07	111.19	89.41	105.94	87.39
22/01/2020    12:54:34	77.52	101.6	86.98	99.88	82.7	97.71	89.11	110.87	89.52	105.86	87.67
22/01/2020    13:04:34	77.72	101.7	87.28	99.85	83.47	97.62	89.23	110.53	89.63	105.76	87.83
22/01/2020    13:14:34	77.06	101.8	87.43	99.84	82.75	97.59	89.33	110.31	89.95	105.67	88.27
22/01/2020    13:24:34	76.44	101.9	87.71	99.81	84.8	97.53	89.67	110.1	90.22	105.59	88.6
22/01/2020    13:34:34	75.33	101.9	86.74	99.75	82.68	97.49	89.77	109.86	90.69	105.49	88.99
22/01/2020    13:44:34	74.84	102	86.76	99.72	84.07	97.47	90.06	109.66	90.56	105.39	88.85
22/01/2020    13:54:34	75.14	102.1	87.85	99.65	85.09	97.5	90.03	109.47	90.71	105.3	89.06

22/01/2020    14:04:34	76.63	102.1	87.94	99.57	84.64	97.45	90.17	109.31	90.72	105.22	89.24
22/01/2020    14:14:34	77.78	102.1	88.25	99.5	82.22	97.45	90.25	109.15	90.98	105.15	89.44
22/01/2020    14:24:34	78.07	102.1	88.01	99.42	82.48	97.41	90.42	108.99	91.38	105.09	89.86
22/01/2020    14:34:34	77.52	102.2	87.63	99.35	84.08	97.44	90.33	108.9	91.22	105.02	89.88
22/01/2020    14:44:34	77.02	102.1	86.94	99.29	82.81	97.44	90.58	108.76	91.5	104.97	89.98
22/01/2020    14:54:34	76.66	102.2	87.36	99.22	84.98	97.4	90.64	108.65	91.42	104.9	89.96

## 20.2 Graph testing final prototype – REV'IT! & Intrepid (04/01/20 – 09/01/20)



## 21. Problem solving

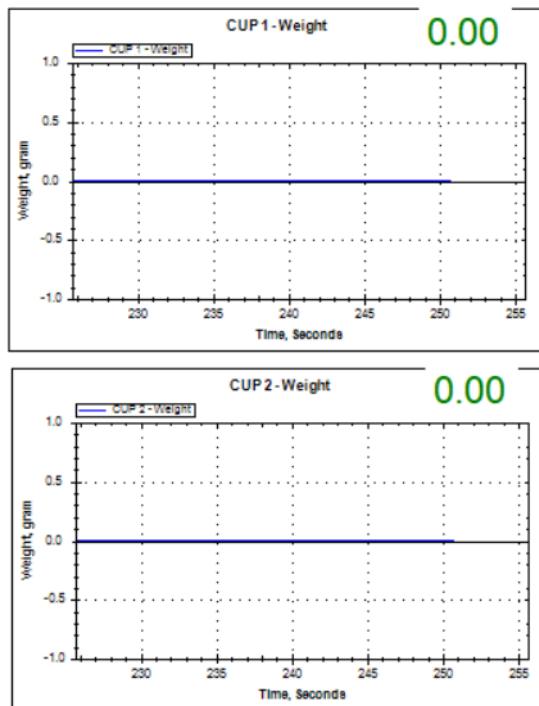
### 21.1 Accuracy problem solving

At the begining in the first experiments all of the load cells (weight sensor) measured values in the format like [number] grams but we analyzed that we don't see most of the changes in weight because of only showing the first digits after that comma. Because of that the first experiments were not that successful. Afterwards I did software changes and the accuracy of the sensors started to be with two signs after the comma for examples 140.99.

However because of this change in the project we started to have way better results in the experiments and we could analyze the behavior of the textiles. Also was really visible how and when there were changes in the values.

### 21.2 Burned sensors

There were some problems on the final prototype after the Saxion Festival Smart Solutions Semester caused from visitors that pushed to much the load cells or damaged some of the sensors. I tested the load cells but as the picture below they always was giving zero value and does not matter if there is something on the metal plate or not. I tried so many things to make it work but after 3 or 4 hours I figure out that the sensors are not discalibrated and they are totally burned. After that took me several minutes to put the new load cells and test them and afterwards I figure out that one of chips that is connected with the load cells is burned. I change it and test the prototype again. In the end everything start to work.



## 21.3 Defected Chips

I received an overdelayed order from TinyTronics. We ordered the last two chips HX711 of our prototype. But we received the package with big delay and in the end the chips in the package were defected. They were burned. I contacted the company and told them the problem. After that I tried to analyze how to fix the problem. In the end I change some components around the chip and they start working again.

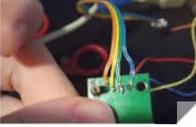
HX711 - Problem Inbox ×

 **Dimitar Rangelov** <dimitar.rangelov9@gmail.com>  
to sales ▾

Fri, 17 Jan, 17:34 (7 days ago)

Hello,  
I called you before few minutes about the problem with HX711  
I also made you a picture of the last HX711 that I order. They are without the MH article on the silkscreen.

**4 Attachments**



TINYTRONICS to me ▾

**TinyTronics - Sales/Support - Friso**



## 22. Skype interview Jorrit Memel

Respondent: Jorrit Memel - Lab coordinator REV'IT

Interviewer 1: Femke Visser – Chairman, Quality Manager,

Interviewer 2: Isabel Wesselink - Quality Manager

Interviewer 3: Harold Kip - Mechatronic Engineer

Interviewer 4: Dimitar Rangelov - Embedded Engineer and Software Developer

Interviewer 5: Le van Hoang Minh - Embedded Engineer

Interviewer 1: 'Hello Jorrit. How are you?'

Respondent: 'Hello Saxionners. I'm fine, thank you. How are you doing?'

Interviewer 1: 'We are doing great, thank you. "We would like to ask a few questions regarding the first draft of the project plan. First of all, what did you think about the project plan?"

Respondent: 'Required to a standard. In a standard the only thing that is within that standard is safety issues. Like physical safety issues. And the standard is, I will write it down is the 17092.'

Interviewer 1: 'Was it 70 or 17?'

Respondent: '17, it is the cycle garments most protective. And I can get you that one. If I have to provide it to you that's no problem. I will write that down. So, what happens, so like I told you again. REV'IT! Is in the workgroup nine commission and the 17092 is the standard that makes sure that you can certify your garments that their safety use in a couple of categories. We compose that standard together with some other companies, together with smaller laboratory. And then it has to go for formal voting. The EU commission has a consultant and that consultant will take a look at the standard and see that you have done your job right and that what's written in that standard is actually state. One of the main complains about the consultant was that we didn't talked about comfort. So, getting wet, getting warm, getting cold. We as a company think that we shouldn't do so, because it's a leisure work. So, it's not professional use it's for leisure. And if you talk about standards are, I mean, they need to comply to certain conditions. Then were talking about professional use. So professional use. There's a difference between professional use and to leisure use. Meaning that if it's cold and you're owning a bike. You have the choice whether not to get on your bike or not. Same with raining. So, you can do an assessment if you want to go drive your bike or not. If you're using it in a professional way if you're a police agent of whatever then you can say today, I'm not getting on my bike, because it's raining. So that the difference between the two. And that said we are interested in the comfort level of our rider. We want to make sure that you can stay dry but staying dry versus actually staying dry is not that hard. We have the ISO in the lab for that. We have the water test and you get a pretty decent idea of what is happening. For breathability it is a different story. The test we are using right now is referring to ISO. But actually, the standard we're using right now is the ASTM. So we're testing it according to ASTM 96/95. If you read that test method, you will see that the calculation to calculate the breathability of the fabric is done by using a graph. And of your comments was do we need to measure the weight of the cup at the beginning and end or do we need process. If you read that standard you see that you have to constantly measure the cup. The MVTR is measured by if you look at the graph. I'm taking a certain section out of the graph where the graph has a

certain in climb. Therefore, you need to constantly measure what weight it is. You see the graph you go look for that climb and that's what telling you what the MVTR uses the calculation. Now if you read the standard that you will find out. We can't do that, so we do our own test right now. So, we measure it in the beginning and at the end. We calculate the MVTR but that will mean not according to the standard. But also, a problem for us is that we, where we talked about like gore, gore needs to have a build up before it starts to work. But if you have fabrics like event for instance immediately starts to work. But we can't see that, we can't see what's happening during this period. That the cups are in the oven. So that's one reason more that, to have a constant reading of the cup. So, two things, we're using the ASTM 96/95 we need to measure the cup constantly and this is the test that you are going to do is the right from the discussion that started when we had the 17092 out for voting. And that doesn't mean necessarily agree to that. That we should indicate waterproofness in the cloth value or the breathability of the fabric. Because the breathability of the fabric, just open a zipper and you have more breathability than any magical fabric will do. So, we don't necessarily agree with that. But we do think that it's important for us to know the breathability. And what you're going to do is most likely going to look at the ASTM 96/95, because if you take any of the, if you find another method and you think that way better tell me, and we discuss that. For easy steps this is a perfect start for us/you.'

Interviewer 3: 'Okay great, thank you. Is it possible for you to send that standard over to us? Because currently we aren't able to look into the standards. I found a lot of standards but most of them are, yeah you need to pay 80 bucks to see it.'

Respondent: 'No problem at all. I already wrote it down that I will get you the standards. So, you get the 17092. You won't see anything about breathability in there, but we mentioned also that we did the tear and dimensional stability test etc. and that standard will exactly tell you which standard we use and what it should comply to. Not that is important for the research but then you have an idea what the standard is about. So those are our final tests. Purely, the test purely done a physical and chemical. If you see that then you have a better idea better understanding. For your information again, what it tells us. There was a comment about the house consultant. That is the guy that tells you if the standard is okay or not. The house consultant he was, he has a major in environmental circumstances. So of course, he was like hey let's get to the occasion. What I read was very strange that if you go on a short ride, then you need a high breathability cause you're only out for a short while. This is pure rubbish. It doesn't matter if you go for a short ride or for a long ride. Breathability is breathability and if something doesn't breathe then it doesn't breathe in short terms then it also doesn't breathe in a long term. So, breathability is breathability. Whether you ride long, or you're driven short. You have to understand that 17092 is mainly opposed by some Australian guy. That want to have their own standard in place. It's about money. If it's not mandatory, still if we talked about membranes and buy a membrane or supplier gets the data related to the membrane. Tested purely alone. So, on itself, but then we don't know what the fabric does. So, we need to do a counter test on the actual fabric itself, otherwise we can claim that something happens. And the jar gives a breathability of 30000 and the membrane itself. If we laminate, it to a glass window. The glass window has a breathability of 30000 so we need to access to complete, so membrane and the fabric itself. So that one of the reasons why we want to do this test, because everything our supplier says are data again purely based on the membrane itself. That's why we are also not that interested in the membrane itself because you can have a high breathable membrane, but it has a sort of chemical composition and some chemical composition work rough, with the same chemical composition. But if you use it with



a fabric that has a different composition then it can be reduced to zero of the breathability of the membrane. So, for us the complete package is important.'

Interviewer 3: 'I also found out that two years ago you actually had another Saxion project with also a lot of data from humidity and temperature sensors which were woven into a suit. Is it possible to get that report? Because in that report might be also data relevant to us.'

Respondent: 'Of course, I will do so. No problem, I will get you that report too. actually, so you know the first group came half and the second group came three quarters. So, there are two groups who worked on that and I will ask research and innovation to give it to you. No problem.'

Interviewer 1: 'Okay great. So, we composed the main and sub questions. Well we had some comments from Jenny to make the main question less long. What did you think about the main question?'

Respondent: 'While I'm reading, I see on page two the comment why it is important to measure the breathability. As I said the first point is that we can't use the data from our suppliers. They say the membrane has a breathability of 20.000 RET. That is the membrane. But what does the whole package. What does it mean if it is laminated to another fabric? So, we need real data and not statistics from suppliers. But also, what we talked about is that okay we keep our drivers save with the products we have. Now we want to keep them comfortable as well. It is important to have them comfortable as well. The main question is way too long. It is page three if I'm not mistaking. To what extent can a device be developed which can gather the data of the evaporation time, humidity and temperature in the oven. I think the fact that you have the evaporation time, humidity and temperature in the oven and the weight Is sort of. If you want to make the main question shorter it is to be detailed. I would say make a device that can measure breathability. That is enough. That is the only thing I want to know right now or what is the breathability of the fabric. And that we need to know the evaporation time, humidity and temperature in the oven, the weight of the six cups. The time the time itself. We need to know the temperature and we need to know the weight of the cups. It would be super nice to know what the humidity is inside the cup and on the outside of the cup. The same with temperature. It would be super interesting to know what the temperature is within the cup or outside the cup. But those are steps that will come later. First you want to build a machine that measures breathability. So, I would keep that simple. That is your main task and in the sub questions themselves. Because you also had some comments on that if I'm not mistaking.'

All interviewers: 'Yes'

Respondent: 'She says it does not need to be in detailed. Just the device which measures breathability.'

Interviewer 4: 'But for example, we can make this device to measure breathability and after that everything like time and weight can be our sub questions. In that case.'

Respondent: 'I do agree on that. I would do it like that and make sure that you prioritize. So, your sub questions okay we make a device which can measure breathability. Sub question one; Can you make something that weighs the cup at all time? Sub question two; Can you make something that measures the temperature at all time? And then step by step you go to

the more difficult question. But also, to the questions if they are not necessarily fulfilled than that isn't a huge problem. But if we don't know the weight, if we don't know the temperature then we have kind of a problem.'

Interviewer 1: 'Yes, I can imagine. I think we can definitely work with all this information. If you can provide us the standards, we can read them all through. We need to change the problem analysis a bit more, so it is more detailed.'

Respondent: 'Just give some context. I don't necessarily agree with Miss Hesse. For me you don't hand out this report to someone on the street and ask; Hey do you understand what we are talking about. We are talking together within this project. But if Saxion want that that is fine. But if you give it some more context what breathability has to do with the comfort level. If you do research, for instance, the Australian guy wrote keep in mind a lot of politics do. It is not necessarily scientific piece that is completely true. But for that matter it doesn't hurt either to say so. If you rewrite the sub questions and prioritize them, please. Tomorrow I will be here for the whole day and after that on Wednesday, Thursday and Friday I will be climbing in Italy. So, I won't be here. It is also to get in touch with the outside world. But I think you have enough to structure the document.'

Interviewer 1: 'Yes, definitely. I think we can go forward with this information. Well we have to hand in our project plan the 22<sup>nd</sup> of September. So, we will work with your feedback and with Jenny's feedback to adjust the project plan and we will update you of course.'

Respondent: 'Perfect, sounds great. And I will make sure you will get the standards, starting with the 17092. Sometimes I will provide you the older standard so you will not have the most recent standard, but for this it doesn't matter much. As long if you have an understanding. Especially the ASTM 96/95 and the calculation of the breathability. What you also already found out is that this isn't a very. We do this for ourselves. If someone else will use this standard they will build it another way and would have different outcomes. For us it is not important that we have an outcome that we can actually use towards our suppliers. For us it is to get a feeling of the fabrics we use and to indicate them according to our own test method. So, it doesn't have to be an international standard. It is something for us. And that said I will forward you an email from Intrepid. Intrepid is a supplier of a membrane and had some interesting things to tell about test methods for breathability. And why he doesn't like our testing method. But I will send that to you as well.'

Interviewer 1: 'Great. In our last email we mentioned the cups and all the kinds of fabrics which we requested. Yes, you will send this to us.'

Respondent: 'Yes, I will make sure I will send it out tomorrow. So, you will have the stuff you will need to start with. You required one cup if I'm not mistaking?'

Interviewer 3: 'Yes, because it is a cup mainly to take measurements from and do a reference against. If we have the cup it is possible to make a drawing and send it out to make cheaper ones. Because to drill in a four-hundred-euro cup to put the sensor in it is a little bit risky.'

Respondent: 'Yes, I will send one of the cups out to you as well. If you make sure I will get it back in time and it is still in one piece I would be very grateful. No problem.'

Interviewer 1: 'To what address are you sending them?'

Respondent: 'The address that you are going to mail me.'



Interviewer 1: 'Okay, that is great. Yes, then we will await your answer and you will hear from us as soon as possible with the new project plan and if we need anything else or have any questions.'

Respondent: 'Yes, let me know. I'm here tomorrow all day and today as well. If you have any questions do not hesitate to call.'

Interviewer 1: 'Great. Well, thank you for everything.'

Interviewer 3: 'Do you have any questions left for us?'

Respondent: 'To be honest no. As long as you start with the ASTM 96/95 then you will have a better understanding for what is happening and what we are doing. And again, I'm not asking you to build an ISO whatever machine. I'm asking you to build something that can do these measurements and is purely for internal use of REV'IT! Itself. So, we have a better understanding about the breathability of fabrics. If you are going to create everything there is to know about membranes than you will know that if you want to test them in real life, some of you mentioned it, then we will have a hard time. During the process you find something that you think is worth to incorporate in the testing method because you that is giving you a closer represents in real life then go ahead. Be free. But start with the basics and see how far you will come.'

Interviewer 3: 'Because I already found some papers from a university with the comparison of standards. It would be interesting to look at it.'

Respondent: 'Yes, and if you can forward that paper to me as well. So, that is a question for you indeed. Then I will be very thankful for that. But start with the 96/95 and if you think it is completely rubbish than you email me and tell me Jorrit that is completely rubbish. We have way better methods in mind. Be my guest.'

Interviewer 3: 'I don't have any questions left.'

Interviewer 1: 'Great. I think everything has been answered.'

Respondent: 'Yes, fine. Goodluck and again I'm here today and tomorrow for any questions.'

All interviewers: 'Thank you.'

Respondent: 'Thank you. Bye.'

