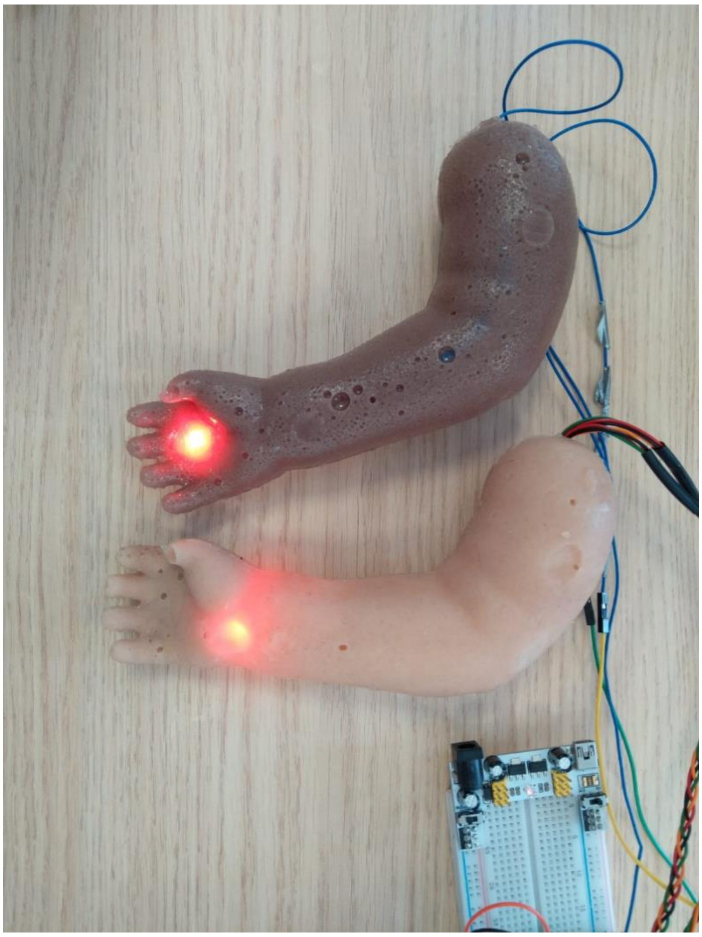
Infant Life Support Simulation

rapport



Location: HAN, Ruitenberglaan 26, 6826 CC Arnhem
Client, Project owner: MSc. Johan Korten, Docent HAN Arnhem
Project advisors:

Johan Korten	|	Product Owner
Irene van der Zee	|	Industrial Design and Engineering
Lieke Oving	|	Industrial Design and Engineering
Sterre Wouters	|	Industrial Design and Engineering
Lars van Zanten	|	Industrial Engineering and Management
Joost van Andel	|	Electrical Engineering Embedded Systems
Dingzhu Chen	|	Electrical Engineering Embedded Systems
Tharsen Kumar	|	Electrical Engineering Industrial Power Systems
Ramon Jansen	|	Electrical Engineering Industrial Power Systems

Preface

Management Summary

Manager summary, briefly describe the content of this report (non-technically)

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1. Problem definition

Name	Role	E-Mail	Phone
Johan Korten	Product Owner	Johan.Korten@han.nl	
Ramon Jansen	ELT-IPS	Rw.jansen2@student.han.nl	
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The problem is that the infant life support simulation needs more additional research to fully get working and meets the users demands. These are documented in the Master Thesis: Towards a Modular and Open Patient Simulator written by Mr. Korten.

2. Scope per course, division of roles, stakeholders and users

2.1 Industrial Engineering and Design (IDE)

In order to help the medical students better understand what to do in a real-life situation the industrial engineering and design students will focus on the realism of the patient simulator. As to achieve to make a real-life patient simulator they will have to do research about the physical aspects such as hair and nails, as well as to the feedback the patient simulator will give, such as colour changes and spit up.

2.2 Industrial Engineering and Management(IEM)

The only Industrial Engineering and Management student will look at the business side of the infant life support simulation project. This includes making a Marketing plan, stakeholders' analysis and financial plan. Beside the business side of the project the role of scrum master is for the student at the start of each sprint the IEM student will pick tasks from the backlog.

2.3 Electrical Engineering Embedded Systems (ESE)

As Embedded Systems Engineers It will be our task to make sure all small electronics and their programming meet the requirements. We will focus on the electronic parts that handle the inputs from the sensors and the output through actuators. We specialize in the programming behind these parts and will work closely together with IPS to realise the hardware side.

2.4 Electrical Engineering Industrial Power Systems (IPS)

Industrial Power Systems is mainly focused on designing and implementing the following type of systems:

- Power conversion (PV, wind turbine, SMPS)
- Control system
- Power transmission
- Automation
- Electromechanical systems
- PCB Design (conform EMC guidelines)

The power conversion, control systems, electromechanical systems, automation and PCB Design will be important parts of this project. IPS has to work closely together with ESE to make sure that modular, compatible and future proof design of the systems are established.

IPS/ESE need to be working closely with IDE and IEM as well. Especially since IDE determines what is considered as the wanted User Experience by the stakeholders and IEM makes sure that there will be looked at business side of the Infant Life Support Simulation project.

IPS/ESE has to make sure that the electronics side of the User Experience determined in collaboration with all disciplines will be translated into a feasible electrical system.

The following systems are going to be either designed or revised:

-NTB

2.5 Additional stakeholders

Stake holder	**Study**	**Category**	**E-mail**	**importance**
Fieke Scholten	IDE	Expert IDE	Fieke.Schulten@han.nl	Manage closely
Paul van Wegen	All	Skills docent	Paul.vanWegen@han.nl	Keep informed
Nanda Verheul	All	IC nurse		Keep informed
Johan Korten	All		Johan.Korten@han.nl	Manage closely
Nicolette Post	All		Nicolette.Post@han.nl	Keep Informed
Tim Antonius	All	Neonate nurse		
Theo Peeters	All	Specialist nurse		
Tino de Raad	All	CPR trainer at a child hospital		
Daniel Vijlbrief	All	Neonatologist		
Maarten	All	Master student (specialized in lungs)		
Vivian van Tilborg	All	Children's nurse		Keep informed
Ambu	IEM	Supplier		
CAE	IEM	Supplier	https://caehealthcare.com/patientsimulation	
Gaumard	IEM	Supplier	http://www.gaumard.com/s3201-advanced-multipurpose-patient-simulator	
Laerdal	IEM	Supplier	http://www.laerdal.com/us/	
Andries van Stralen	IEM	Docent	WA.vanstralen@han.nl	Keep satisfied
Katja de Grijff	IEM	docent	Katja.deGrijff@han.nl	Keep satisfied
Marius	IEM	Supplier	marius@skills-meducation.nl	monitor
Ramon Jansen	All	Student	**rw.jansen2@student.han.nl**	Manage closely
Tharsen Kumar	All	Student	**t.kumar@student.han.nl**	Manage closely
Sterre Wouters	All	Student	**s.wouters@student.han.nl**	Manage closely
Lieke Oving	All	Student	**lj.oving@student.han.nl**	Manage closely
Dingzhu Chen	All	Student	**d.chen1@student.han.nl**	Manage closely

Irene van der Zee	All	Student	is.vanderzee@student.han.nl	Manage closely
Joost van Andel	all	Student	j.vanandel@student.han.nl	Manage closely

Category

- **Keep satisfied:** here is the influence high but the interest low
- **Monitor:** here is the influence and interest low
- **Manage closely:** here is the influence and interest high
- **Keep informed:** here is the influence low but the interest high

3. Who are the users?

After reading the thesis from Johan and speaking with two stakeholders from the HAN there is a general idea of who the users are. The nurses we spoke with were very clear that they really wanted to use the infant life support simulation. So the HAN and other universities who teach some kind of nursing. We want to expand the scope of users because they are also potential buyers, so we include everyone who works with baby's and are responsible for their care. The supplier are also users because they can help produce the infant life support simulation.

4. Project goals

The project group has as goal to Help Johan improve his current infant simulation. By implementing realistic interaction and real-time auditive and visual feedback. With a business view implemented on the project, this all before 7th of July.

While this also learning from each other and improving our skills working in a project with a big team. In attachment 1 we listed roles and skills we possess but at the same time we can learn from each other

5. Product Backlog

Nr.	Description	Priority	Category	time	status
1	Implement speakers for auditive feedback (crying, moaning)	1	ESE/IPS/IDE	2 weeks	
2	Implement a way of showing skin discolouration (periphery cyanoses, blushing)	1	ESE/IPS/IDE	4 weeks	
3	Implement heartbeat feedback to the user in groin, ankles and wrists	3	ESE/IPS/IDE	3 weeks	
4	Improve feedback given through the phone app	4	ESE	2 weeks	
5	Improve Touch Sensing Electronics/software including capillary refill	2	ESE/IPS/IDE	2 weeks	
6	Improve measuring of chest compression depth	2	ESE	2 weeks	
7	Improve detection of movement between head and body	1	ESE/IPS	3 weeks	
8	Improve measuring of air movement in the lungs	3	ESE/IPS	2 weeks	
9	Improve automation of lung inflation	1	ESE/IPS	2 weeks	
10	Improve Bluetooth communication with the phone	3	ESE	1 week	
11	Improve logging of feedback results with Raspberry over WIFI	2	ESE	2 weeks	
12	Improve data communication between sensor modules	4	ESE	1 week	
13	Redesign of the power control board. *Note: It might be possible to design one Power supply which can be used in multiple systems. This could mean; two sprints in one See backlog nr. 43*	1	IPS/ESE	3 weeks	

14	Implementing/design of battery system (battery).	1	IPS	2 weeks	
15	Implementing body temperature features in the infant simulator.	2	IPS/ESE/IDE	2 weeks	
16	Improve the communication between MCU and Raspberry Pi	3	ESE	1 week	
17	Implementing Improvement /design of wireless charging system for the infant	1	IPS/ESE	2 weeks	
18	Implementing of moving nostril	3	IPS/ESE/IDE	3 weeks	
19	Making it possible to tube the baby	3	IPS/ESE/IDE	2 weeks	
20	Discoloration (LED's) in the cheeks, hand, feet and lips and mouth region.	1	IDE/ESE/IPS	2 weeks	
21	A piece of umbilical cord attached to the belly	3	IDE	1 week	
22	Create a fully removable outer layer of skin made out of silicones	1	IDE		
23	Removable limbs for easy access	1	IDE	3 weeks	
24	Functional audio feedback to simulate a difficult moan during breathing	3	IDE/ ESE/ IPS	1 week	
25	Simulate spit up when there is too much air in the stomach	4	IDE/IPS/ESE	3 weeks	
26	Making it possible to place a catheter.	3	IDE/IPS	1 week	
27	Making it possible to inflate lungs independently	1	IPS/ESE		
28	map all the stakeholders	1	TBK/ all	1 week	
29	Making stakeholders analysis	1	IEM	3 days	?
30	Making stakeholders matrix	1	IEM	2 days	?
31	Doing an external analysis for the project(macro)	3	IEM	3 days	
32	Doing an external analysis for the project(meso)	1	IEM	3 days	?
33	Doing an internal analysis for the project(micro, strategic)	3	IEM	3 days	
34	Making marketing context	2	IEM	2 weeks	?
35	Marketing plan	1	IEM	2 weeks	
36	Financial situation context	1	IEM	2 weeks	
37	Financial report	2	IEM	2 weeks	
38	Statistical report of the financial status of the project	2	IEM	2 weeks	
39	Improve the interface of the app	1	IDE	4 weeks	
40	Researching the user	1	IDE	2 weeks	
41	Sensor that confirms a correct positioned thermal probe. (Rectum)	2	IDE/IPS/ESE	4 days	
42	Wireless connection between monitoring box and infant simulator	4	ESE	1 week	
43	Power supply for monitoring box. *Note: It might be possible to design one Power supply which can be used in multiple systems. This could mean: two sprints in one. See backlog nr. 13*	1	IPS	2 weeks	

44	look into motion sensors and which one is the best for the infant life support simulation.		IPS/ESE	3 weeks	
45	Motion feedback with RGB lights		IPS/ESE	3 weeks	
46	business plan	2	IEM	3 weeks	
47	ABCD-analysis	2	IEM	3 weeks	

Diagram

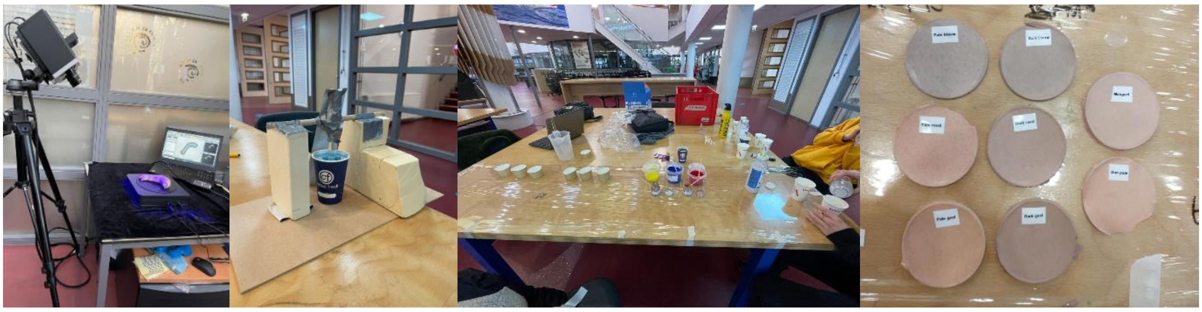
- **1** Priority high: high value to do for Johan and interesting to learn.
- **2** Priority medium: had value to the project but mostly interesting to learn.
- **3** Priority low: no value now or its to big, can be interesting to learn.
- **4** Priority very low: no value and no learning interest.

6. Sprint 0 introduction and orientation

The chapter describes how the different sprints were divided to achieve the goal. The content of each sprint was decided based on the priorities of the tasks in the backlog. The chapters are divided into their respective analysis, their tests and the conclusion.

6.1 Testing silicone skin and mold making

1. Sprint 0 has started off with scanning the arm of the current Life Patient. This all went a bit less smoothly than previously thought. There were a number of problems with the laptop and the object being difficult to scan for the laser. The entire arm was too difficult to scan all at once, so two scans were made of the top and bottom. It took 2 days for the arm to be scanned.
2. When this was done successfully, the scans were aligned in Mesh mixer and adjusted to be printed with the 3D printer. With this print a good basis has been set up to then make a mold.
3. Then the formwork was made using the Maker Case program. This formwork is made from an acrylic sheet that was cut with the laser cutter. This was easily put together by means of finger joint and glue. After this the edges were sealed so the tray would not leak.
4. As a small test, a mold was made of the baby's hand. This showed how it worked, how it would feel and the thickness of the silicone.
5. After this, different skin swatches were made from different types of silicone. By giving these silicone swatches a pigment, it was possible to determine which type of silicone was most desired. From this, one type of silicone has been chosen.
6. After a choice was made which silicone to use, it was tested with the pigment and fibbers (flocking). The light transmission by means of RGB LEDs and the thickness of the swatches were examined. It is now clear which silicone, colour and fibbers are suitable. This can now be used for casting the arm.



6.2 Auditive feedback

6.2.1 Speaker

Research

In order for the infant simulator to make sounds it needs a speaker. This speaker will also need an amplifier and it will need to get an input signal from some source. When looking at small form factor speakers there are generally two types that can be considered. These are the conventional electromagnetic loudspeaker (AKA dynamic loudspeaker) and the electrostatic loudspeaker. Both have their advantages and disadvantages.

Some of the attributes that we look at in the speaker are:

- Volume
- Clarity
- Resonance
- Size
- Frequency response
- Power consumption

Electromagnetic speakers tend to be slightly larger than electrostatic speakers, require more power for the same volume and vibrate more due to a heavier diaphragm. On the other hand, they have a better frequency response specifically in the lower range and are able to produce a clear sound more easily.

Conclusion

With every aspect taken into consideration we think the electrostatic speaker will be our best pick. The only uncertainty is whether it will be able to produce a clear enough sound. In the next sprints we will test an electrostatic speaker which will tell us if it is suitable for our project.

For more information regarding the technical aspects of our choice in speaker see “Speaker research.docx”.

6.2.2 Sound samples

Research

A baby can make a lot of different sounds which can mean a lot of different things. Not all sounds are relevant to us though, only the sounds that have significant meaning during CPR need to be simulated.

Some important sounds that need to be simulated are:

- A healthy sounding cry to simulate responsiveness.
- Stable breathing to simulate responsiveness.
- Coughing to simulate the regaining of responsiveness.
- High pitched noise during breathing to simulate a stridor.
- Other cries that simulate less urgent needs for the baby.

Conclusion

It is important that the baby has a good assortment of sound samples that will be able to give the user all the feedback they need to correctly perform the CPR.

For more information and research about sound samples see “Audio sample research.docx”.

6.2.3 Hardware connection & Software implementation

The first thing to do is to connect the SD card module and the speaker module to the SAMD 21 microcontroller.

The communication protocol between SD card module and the SAMD21 microcontroller is SPI.

The pin connection is:

MOSI - pin 11

MISO - pin 12

CLK - pin 13

CS - pin 4

In the software, we need two steps to set up the SD card module:

```
// SD chip select pin (with ethernet shield : 4)

#define YOUR_SD_CS 4

// setup SD-card

if (!SD.begin(YOUR_SD_CS)) {}
```

these steps above make the select pin for SD card module become low, so that the SPI communication between the module and the SAMD21 works.

After setting up the SD card, the second thing to do is coding for the SAMD21 microcontroller to play music from the SD card module.

The concept is to create a time interrupt event to generate a summation of impulse signals output in the pin A0, every interrupt event will generate a single impulse signal, then a lot of events will generate a summation of impulse signals, these signals amplified by the speaker will become a music.

First step is to read the .wav file from SD card by using `read(__WavSamples, __NumberOfSamples);` function,

then the data of .wav file will be stored in a pointer named `uint8_t *__WavSamples;`

finally use the function `analogWrite(A0, __WavSamples[__SampleIndex++]);` to generate a single impulse in the pin A0.

6.3 Neopixel LED lights

Research

The LEDs we are going to use have the following requirements, they need to be:

- Bright enough to emit light through the layer of skin.
- Easy to change colour.
- Not generate too much heat.

Our first thoughts went to the WS2812B Neopixel LEDs which we had quick access to. We also tried out smaller single colour LED's but decided that they weren't versatile and powerful enough for our needs. The Neopixel is an RGB LED which has an easy-to-use library for Adafruit boards. This makes it very easy for us to prototype with, which is exactly what we needed. From testing with small patches of skin we concluded that the LEDs are bright enough to shine through the skin. And further testing showed us that they don't produce an excessive amount of heat.

Conclusion
The WS2812B Neopixel is the best LED for us to use during prototyping due to its versatility and brightness whilst keeping the heat generation at a low.

For more information about our LED Research see “LED research.docx” and “Rapportage LED.docx”.

6.4 Power Control and Wireless Charging

6.4.1 Power controller

The Current Power Supply
The current power supply is insufficient due to the following issues:

- Temperature issues (the power control board gets too hot)
- EMC issues

These issues are based on information provided by the PO. No tests have been performed by this group to verify the above stated issues.

Power Supply Requirements

The battery and it’s BMS are part of the Power Supply System.
The requirements are as follows:

- The battery needs to be at least 34Wh. This is based on the power consumption of the system and it’s peripherals and on the fact that the battery needs to last at least one training cycle and exam (4 hours total).
- Wireless charging must be possible
- Total peak power of 50W
- Communication with the power board is necessary (to share the remaining battery voltage etc).
- 5V (max 4A) and 12V (max 2.5A) output power connection. Power is converted locally if 3.3V is needed.
- Charging through DC power supply must be possible.
- Qi protocol is should be used for wireless charging.

Power Supply System Architecture
Shown in figure 1 is the proposal of the System Architecture of the power supply.

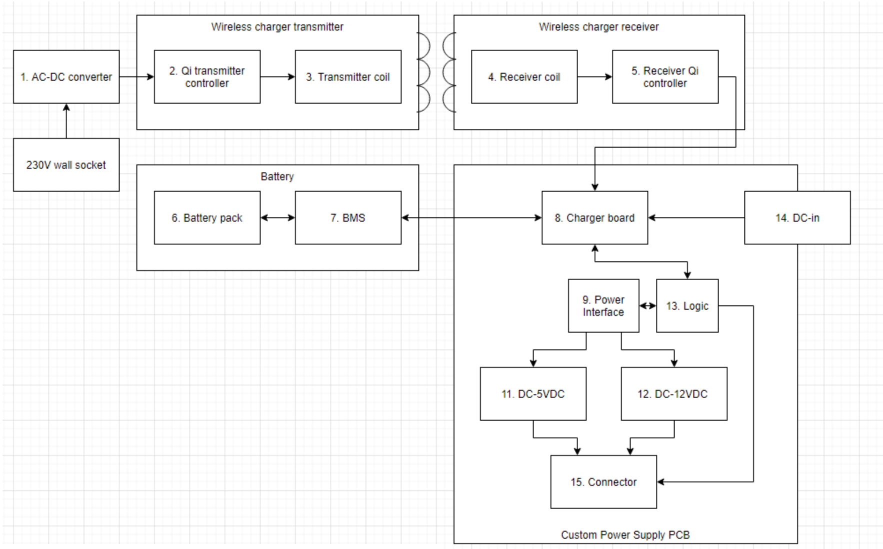


Figure 1: High level architecture of the Power Supply

From this figure can be derived that one new PCB should be designed. The BMS should preferably be an off the shelf part.

6.4.2 Wireless charging research

Field research

Measurements on the current wireless charging system are performed. The temperature was measured while a 5 Ohm load was connected so a current of 1A would flow.

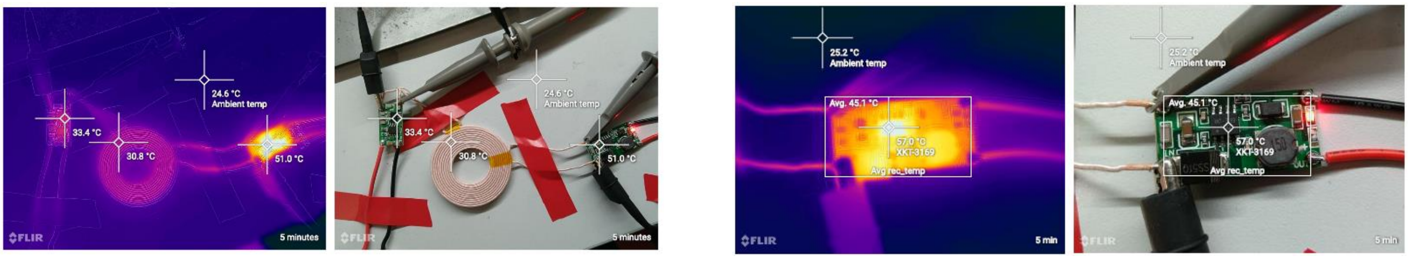


Figure 2: Wireless charger test setup

Within two minutes the driver reaches a temperature of 45 degrees Celsius. After 5 minutes this temperature stabilizes until around 51-56 degrees Celsius. As you can see in figure 2, this is the temperature when the setup is in an environment which can be approximated as open air. This indicates that the temperature will even rise further when the setup is in an enclosed environment (like in the body of patient simulator). On top of this, the charger has a poor efficiency, when there's no load connected the wireless charging system still consumes 150mA. The efficiency is especially poor at the secondary side, this is mostly due to the switching losses caused by the buck converter.

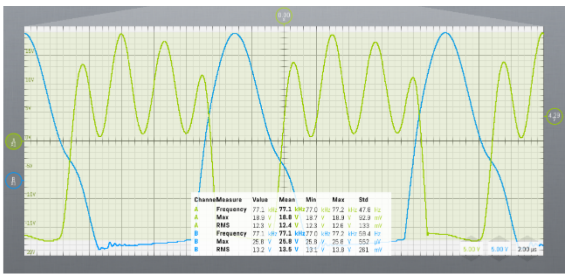


Figure 4: Oscilloscope capture of well functioning steady-state charging

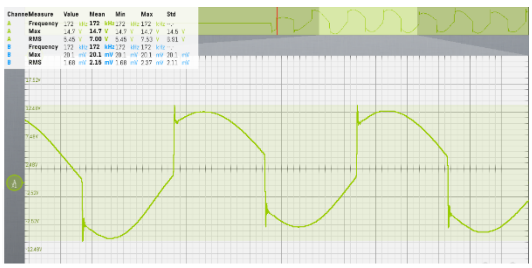


Figure 3: Oscilloscope capture of idling transmitter signal

From the graphs above (figure 3 and 4) can be derived that the system doesn't communicate through the Qi protocol, which in unfortunate, since there's a lot of hardware available at an affordable price point for this protocol. Figure 4 shows a well functioning wireless charging system using the Qi protocol. Figure 3 shows the idling signal of the transmitter. The green graph (transmitter signal) in figure 3 should be similar to the green graph shown in figure 4.

Conclusion

To summarize the above:

- The wireless charging systems gets too hot, this will get worse in an enclosed environment.
- Poor efficiency which would lead to the need of a higher capacity battery.
- Not compatible with the Qi protocol
- Safety can't be confirmed
- The charging coils are voluminous and rigid

Therefore we conclude that it is better to switch to a new wireless charging system. Preferably an off the shelf solution. For charging a standard wireless phone charger should be sufficient.

6.5 marketing context

In this chapter is going to be look at the marketing of the project. Therefore is written a marketing plan context where is described what is research and the goal. A couple of them are finding out how the infant life support simulation lay in the marked and who are the customers. Also there is research to continue the next sprint with researching marketing and marking it a full marketing plan. The possible to make a business plan is also looked into. Below is are the five competitive forces and there explanation. (Porter, Understanding michael Porter, 2012) (Porter, Competitive Advantage, 1985)

The five competitive forces

In this section we are analysing the meso environment of the Infant life support simulation. Therefore we use the five competitive forces from Porter. Two tools are going to be used the get a general idea of where the business stands. The tools contains multiple questions for each competitive force from very agreed to very not agreed. The two tools will be compared to see if the results look like each other. (mindtools, 2021)

- **Competitive Rivalry:** the strength and the number of competitors
- **Supplier Power:** how easy a supplier can increase its price
- **Buyer Power:** how easy customers can drive your price down
- **Threat of Substitution:** the likelihood that your customers find a different way of doing it
- **Threat of New Entry:** the ability for people to enter the market

Below you can see the five competitive forces address to the Infant life support simulation with scores. In the attachments you can find all the questions that where answered to give these scores.

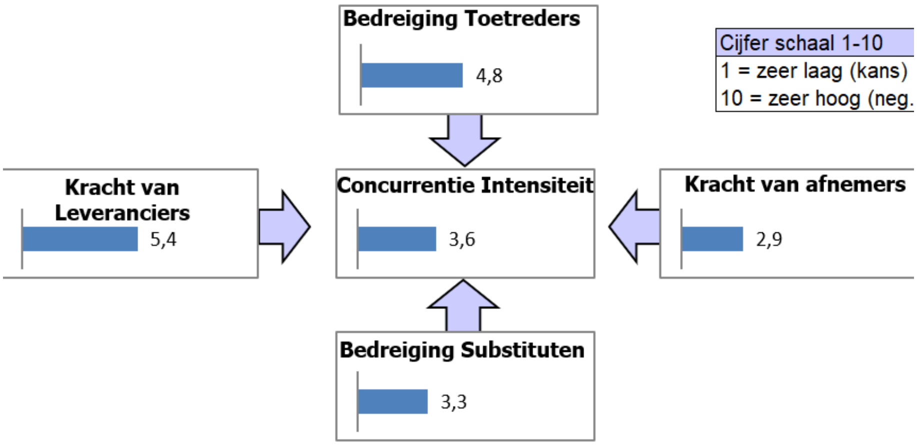


Figure 1the fife competitive forces, Infant life support simulation

conclusion

Below you can see a filled in diagram of the five competitive forces.

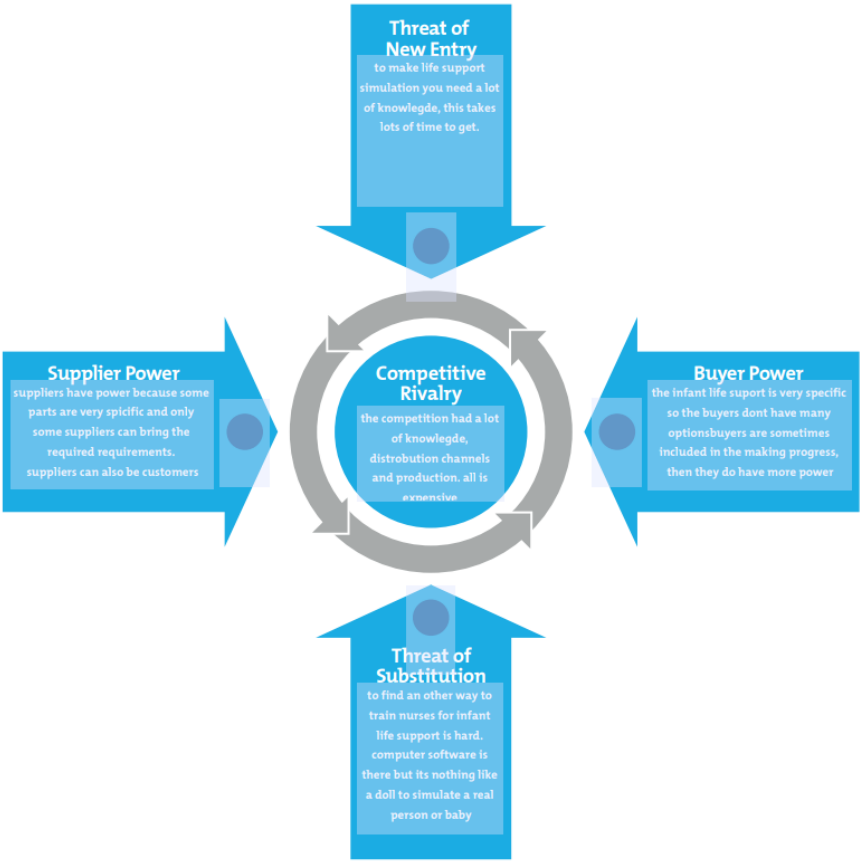


Figure 2 conclusion five competitive forces

In the file, IEM-B-marketing analyse, you can find more information about this subject. In sprint 1 will be done the tasks of who are the customers and other parts of the marketing plan.

6.6 stakeholders

in this chapter there is being looked at the stakeholders of the Infant Life Support Simulation. By starting to identify all stakeholders for the project and of each faculty. After that the stakeholders will be categorized on intern, extern, interface, primary and secondary. the third part is prioritizing the stakeholders on influence and power. If that is clear, we determine the stakeholder's approach by making tabulation. As last the relations between the stakeholders is showcased

The full file contains a more detailed explanation therefore refer to the document 'stakeholders analyse'.

Below is going to be explained how the different stakeholders are approached, therefore are four option to do so. if that has done, they are placed in a tabulation to get the picture clear.

INFLUENCE				
HIGH	KEEP SATISFIED	Vivian van Tilborg	MANAGE CLOSELY	Johan Korten
		Nanda Verheul		All group members
		Fieke en Johan		HAN
		Katja and Andries		
LOW	MONITOR *(MINIMUM EFFORT)*	Tino and Daniel	KEEP INFORMED	Nicolette Post
		Tim and Theo		Paul van Wegen
		Customers		Maarten
		Radboud University		suppliers
		LOW		HIGH

INTEREST

below is going to be a diagram of the relations between the stakeholders. There is given a score from one to five to each stakeholder. Five mean a lot, a lot of interest and 1 means little.

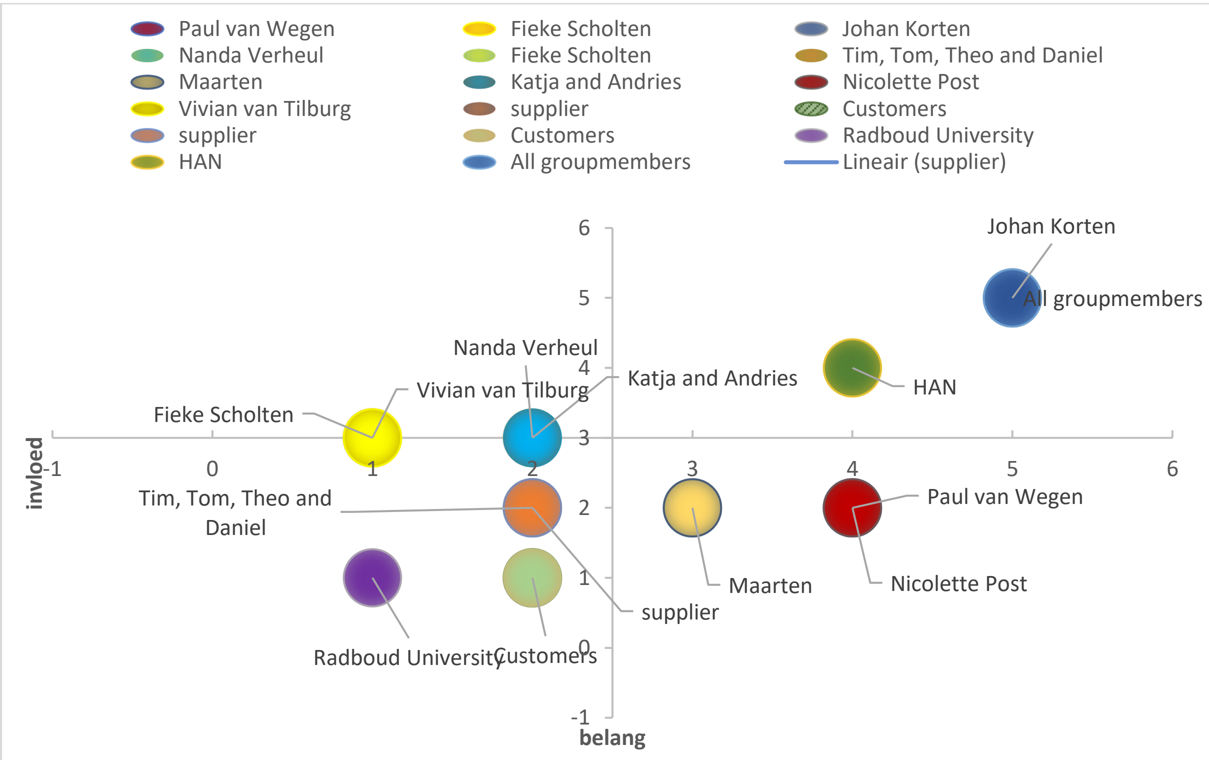


Figure 3 relations between stakeholders

Conclusion

After the writing this analysis the following thinks are clear know.

1. Because the S6 project is aimed at working together, all group members are important stakeholders who are to manage closely.(manage closely)
2. Also its clear to see which stakeholders want to be updated with the progress and need to be invited to meetings.(keep informed)
3. Some stakeholders don't want to be updated, they only want there demands to be met. (keep satisfied)
4. The stakeholders who wants to be updated at the and of the project with the progress or are situational needed for council.(monitor)

7. Sprint 1

7.1 Who are the customers, 6W's of Ferrel

the customers analysis will be done with the method 6W's of Ferrel. Here you analysis the external environment of the business and the goals is to find what the wishes and needs are. Wherefore stakeholders and potential customers are interviewed and desk research will find new potential customers. (Marketingscriptie.nl, 2021) (de Groot & van der Sluijs, 2008) (Eelants, 2019)

The Six W's:

1. Who are the current and potential customers?
2. What do current and potential buyers do with our products?
3. Where do current and potential buyers buy our products?
4. When will current and potential buyers buy our products?
5. Why do current and potential buyers buy our products?
6. Why don't potential buyers buy our products?

Conclusion:

The infant life support simulation project had a lot of potential to do well in the market. There are:

- lots of potential customers – and a lot to of businesses area's that can be win over to see the importance of the product
- small group of concurrent – everyone is focussed on there small part of the marked, what is letting same parts open.
- Blue ocean – there is open marked for the type of product the project is aimed to be
- Price, quality and functionality.

Some thinks need to be considered. It's a project from a university of applied science and that why the business site is lacking. The question of how will profit will be made is less important then what knowledge it gained. That why the follow business models are suited for the project.

- HAN based – let student produce the infant life support in the workshop of the HAN. This why the price will stay low, but the customers get limited products and the service would be lacking from time to time.
- Sell it to a competitors – they have the process line and business model in place to make and sell the project. The HAN will make less money but the knowledge will go to use.
- Start-up – after the project is finished successfully start a new business with all the risks and benefits with it. Find you own suppliers and manufacturers and get you infrastructure to sell

it to the customers. Manufacturing, warehousing, outbound(sending, selling, brand awareness and service.

7.2 Wireless charging

As stated previously in section 6.4, one of the requirements set by the Product Owner is the possibility of wireless charging. By prior research was unfortunately concluded (see section 6.4) that the available unit was not sufficient. So a new unit needs to be designed or bought off the shelf. The biggest bottleneck of wireless charging is it's inefficiency. The requirement is set as follows:

- The battery of the patient simulator needs to be able to be fully charged (which means that each Li-ion cell is at 4.1+V) within 5 hours.

Most available Qi compatible wireless charger receiving modules are rated at 5V output with max output current of 1A. This is equal to a maximum of 5W of charging power.
This means that charging a battery with a capacity of 35Wh (which is slightly more than the minimum stated is section 6.4) would take *at least* 7 hours (eq 1. $t = \frac{J}{J/s} = \frac{35Wh}{5W} = 25.200s = 7h$).
Two distinct options were considered:

1) Look for a Qi compatible receiver unit with a higher power rating and preferably a higher output voltage.
2) Use multiple parallel coupled 5W Qi compatible receiver units.
3) Other wireless power transmission protocols

Option 1. has been ruled out by high cost, low availability and Qi compatibility issues.
Option 2. has been further researched.
An example of a different kind of wireless power transmission protocol is Air Fuel

Two additional problems with option 2 is that:

1) The 5V output of the receiver unit needs to be boosted since the nominal battery voltage is determined to be 14.8V or higher (4 or more series connected 18650 Li-ion cells). This would introduce more inefficiencies.
2) This option would require more surface area since multiple receiver coils are necessary.

Problem 2 is found out to be easily tackled since the patient simulator has enough flat surface area on it's back which would be sufficient for 3 receiver coils.
Problem 1 is not easily tackled. Boost-converters (especially designed by less experienced designers) tend to have a lower efficiency (around 75-80% for converters with a switching frequency below 500KHz).

With the above in mind, one of the three options below need further investigation during the next sprint:

1) Continue with the option of multiple parallel coupled Qi compatible receiver units.
2) Don't use wireless charging:
    a. Use a swappable battery which is externally charged by a drop-in station
    b. Design the patient simulator and it's mattress in such a way that the patient simulator connects to it's charger connector when it's placed on the mattress

7.3 Power supply

In this sprint, the power supply is further developed into the functional design and more detailed in battery system and converters. The functional requirements are appointed in the rapport "...".

In chapter 6.4 of sprint 0, the power supply requirement could be adjusted, because there are alternatives for the wireless charging. See alternatives in chapter "Wireless charging" of sprint 1.

In this chapter there is discussed about the configuration of power supply board such as the implement of converters and the links such as battery systems and DC-Jack input etc. Before that, the battery systems were looked in technical detail. In the battery system, it is important to know what configuration the battery cells are applied for the infant life support simulator, so that the decision is made for the BMS to apply. Also, what kind of battery cells are applied for the simulator?

Conclusion

For the infant life support simulator, the lithium-ion battery cells are applied in serial connection. This means that BMS is necessary because the lithium-ion battery cells are not stable during charging and discharging. This kind of battery is suitable, because it delivers more current, cheap, and available in all markets, especially suitable for prototyping.

After the clear statements of the battery cells and BMS, the configuration of the power supply board changes a little bit. See below.

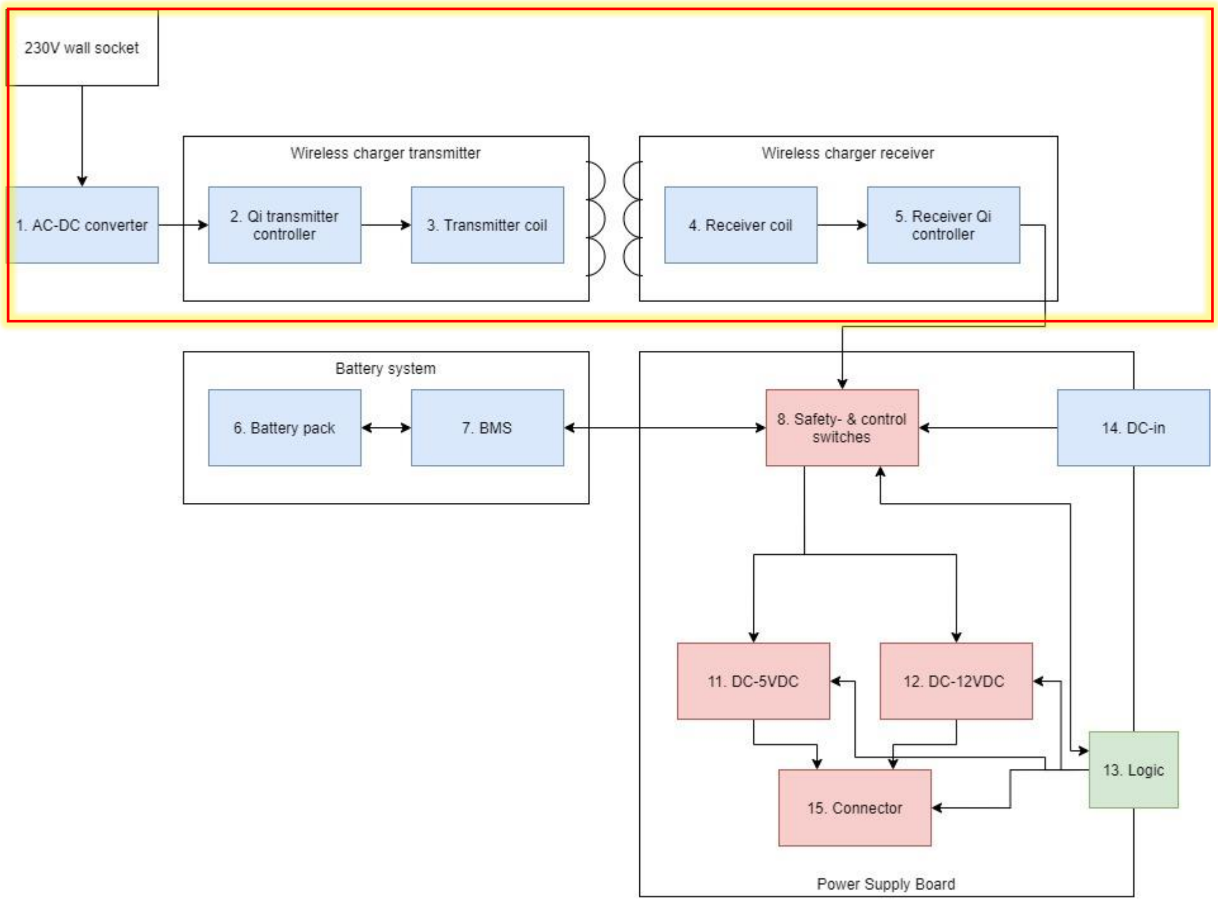


Figure 5: High level architecture of the Power Supply

In the power supply board, there are two converters implemented such as 5V and 12V. Also, in safety- & control switches, there will be safety circuits for the power supply board designed in the next sprints. The safety- & control switches and converters are controlled by microcontroller via logic and it is necessary to have a meeting with ESE and product owner about the controlling of this systems in detail.

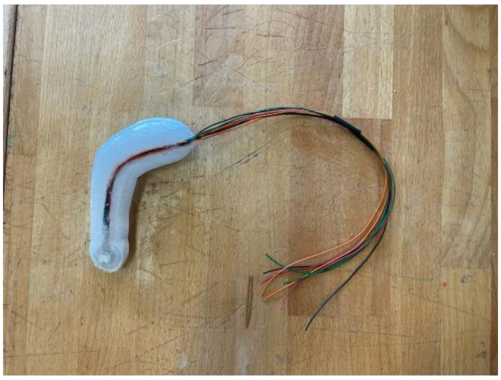
The red/yellow border is the area that should developed. The first solution was the wireless charging, however wireless charging is a inefficient way and there are alternatives that could replace the wireless charging, that is mentioned in previous chapter "wireless charging" and also it needs to be discussed with the product owner.

For further information, see rapport "functional design of power supply.docx" (ELT>ELT-IPS)

7.3 IDE the making of the baby arm with implemented LED's

1. Sprint one started of with the making of the mold. In order to make a two-part mold, the bottom half was first made of clay to hold the 3D printed arm in place, after which silicone was poured on top of it encasing the whole arm. After this had fully dried the clay could be removed and the second part of the mold could be poured on top of it. When the second half dried as well, the mold can be split in two and the 3D-printed arm can be removed.


2. A core is added to the mold. This core is a smaller version of the arm. The first model of the core was not suitable for the vision of the implementation of the LED and the cables. After the correction of the model a second print was made with improvements, including a groove to guide the cables neatly to the end of the arm. The model was also scaled down to make the sure the silicone skin would be thicker and reduce the risk of tearing.



3. With the new and improved core it could be placed in the middle of the mold. This had to be done as accurately as possible to make sure the silicone skin has the same thickness all around. To make sure the core stayed in place little pins were added to the mold on which the core rests.

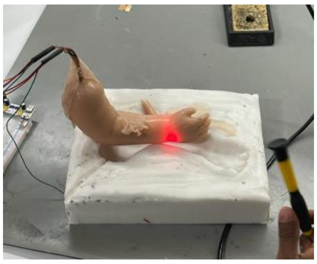
4. The composition of the silicones of the silicones used for the skin has been composed in sprint 0. Therefore, the only thing to do was to convert it to the correct quantities.
The correct composition goes as follows;

- 100ml of component A
- 100ml of component B
- 4 scoops of the yellow fibber
- 1 scoop of the blue fibber
- 2 scoops of the red fibber
- 10 drops of the ‘Dark’ pigment

5. After the silicone mixture was made the pouring could begin. The silicones were a lot thicker than anticipated which made it difficult to pour it through the holes made in the mold. To solve this problem the silicones were first poured the bottom half of the mold, then on top of that the core is placed after which the rest of the silones is poured in the top half of the mold and then fused together. This had to be done swiftly and neatly to reduce the over flow at the dividing seam. To make sure the two halves of the mold stay together four pins were added in each corner going through both halves. When the silicones are poured into the mold the excess of air has to be let out this is helped along with the use of vibrations of the mold.

6. After the silicones had ample of time to dry the mold was taken apart to reveal the finished product. The arm looked great but not quite perfect some improvements have to be made for the next try.

This includes;
- The core has to be made longer to make sure the LEDs are visible in the hand instead of the wrist.



- The cable grooves have to be made on the bottom of the arm instead of the top. This can be done

in a certain pattern to make sure that when the cable is visible it may look like veins.
- The core has to be printed in a softer material for more flexibility, the core is to hard at the moment.
- There are a lot of air bubbles visible in the arm. This can be prevented by using a different pouring method, making sure the assembly of the mold is done neat and swiftly and by making sure the mold is exposed to enough vibrations that way all the air is freed.
- The small unevenness's have to be smoothed out.
- The pouring hole and the air vent create two protrusions. When these protrusions are cut off they leave a visible mark of the skin. A neat way of removal must be devised and it must be examined where these can be placed most efficiently.

7.4 Improvements to the audio feedback system

Speaker testing results

With the electrostatic speaker working we were able to hear that the sound quality was much worse than expected. The audio contained allot of background noise and what was audible from the audio sample was not very clear.

There are several factors that will dictate the quality of the final audio. These are the audio samples, DAC (digital to analogue converter), Amplifier and speaker.

Audio samples: The audio samples have been tested on different speakers to verify their quality.

DAC: The feather M0 board we use has a 10-bit DAC in it. We use this to produce the waveform that gets sent to the amplifier. Because it only has 10-bit precision we can see there are noticeable jumps in the waveform (figure 4). We were able to smoothen out the line using a capacitor, however, this didn't have much effect on the sound meaning this wasn't what was causing the poor audio quality.

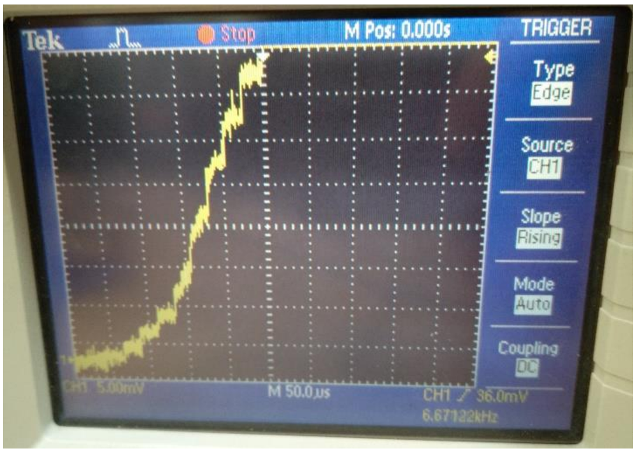


Figure 4 Upcoming flank of sinewave comming from DAC

Amplifier and speaker: The amplifier amplifies the input signal and translates it into the equivalent square waves that are needed for the electrostatic speaker. Looking at the scope image of the output signal (figure 5) we can see that the signal is quite messy and inconsistent which we believe is the cause of the poor audio quality.

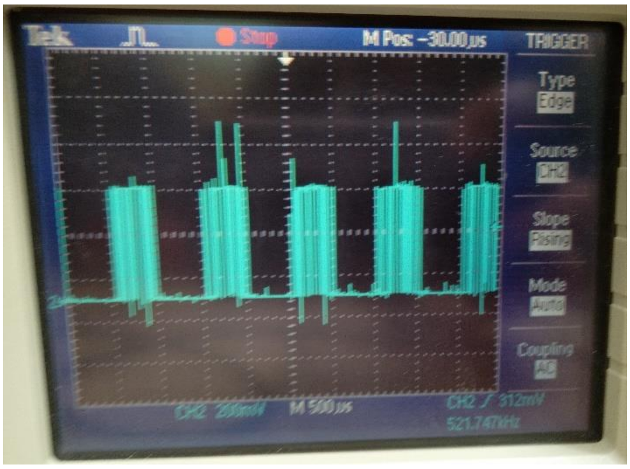


Figure 5 Output signal from amplifier

Conclusion

The amplifier isn't good enough at translating the waveform which results in poor audio quality. The solution would be to either get a better amplifier or use a different type of speaker which uses a simpler amplifier which will be researched in the next sprint.

For more information regarding the testing and research of speakers, see "Speaker research.docx".

7.5 Audio samples

We had a brainstorm session to collectively come up with what kind of sounds the baby can make

- "normal" breathing
- Difficult breathing
- Deep breathing
- "normal" cry
- Happy cry
- Sad cry
- Hungry cry
- Cough
- Suffocation
- Puking
- inspiratory and expiratory stridor
- Moan
- Sound indicating a failed resuscitation

For now we will find an audio sample for all of these situations. One of the problems of gathering all these different audio samples from the internet is that there can be quite a gap in audio quality between the samples, and not every baby sounds the same so there will be a disconnect between the different samples. A solution to this would be to get a recording for all of the sounds that are all done with the same microphone and are ideally all from the same baby.

7.6 motion sensor module concept

There are many methods and also many types of IMUs that can detect head positioning. Currently we have two types of IMUs:

1. The NXP Precision 9DoF breakout
2. MPU6050 6-DoF Accelerometer and Gyro

The group has to test both of their functions and properties (like sensitivity and stability, etc.). Also, the group produced two algorithm methods to detect how students keep the head of the simulator:

1. By comparing the acceleration value difference of two accelerometers
2. By comparing the angle value difference of two IMUs

For the second method, the developers have to design an algorithm to get the precise Euler angles of the head and the torso by using data from accelerometers and gyroscopes. These works will be carried out during sprint 2.

8. Sprint 2

8.1 IDE, the designing of the App and Logo

1. To start of the sprint the IDE students analysed the current corporate identity and logo.
2. Subsequently, mood boards were created about a new corporate identity and logo. These are used as a source of inspiration for the design of the app and the new logo.
3. Then everyone made sketches of interfaces inspired by the mood boards. These interfaces are intended for the teacher's app that will be further developed.
4. After this, all sketches were viewed together and merged into a new design.
5. Sketches were also made to create a new logo.
6. This design of the interface was then drawn up in all user steps and worked out in Adobe Xd.
7. The logo is also elaborated in Adobe Ai below.

8.2 ESE, Audio feedback improvements and Motion sensors

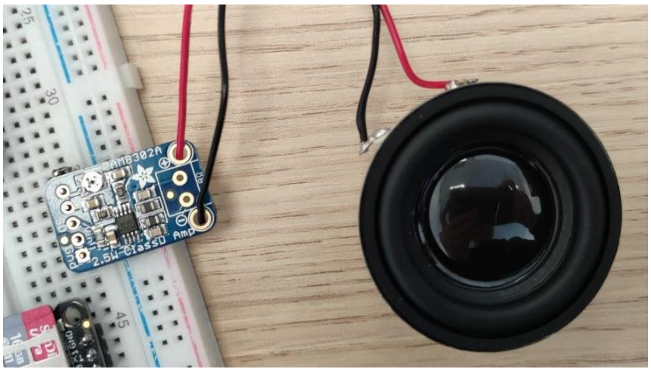
8.2.1 Audio feedback system

1. **Audio feedback improvements.**

After obtaining the new amplifier and speaker that we decided on last sprint we performed some simple test with it. We tested sounds of a crying baby and a clear sine wave. Comparing this to the audio from the electrostatic speaker there was a noticeable improvement in audio quality. Having gotten results from both the electromagnetic and electrostatic speaker we can compare them with each other to see which speaker is better for us.

	Electrostatic	Electromagnetic
Clarity	--	+
Volume	+	+
Vibration	++	-
Power consumption	++	+
Frequency response	-	+
Size	++	+

When comparing the two speakers we can see that the electromagnetic speaker has a clearer sound and better frequency response, but this comes at the cost of more vibrations, more power consumption and a slightly larger speaker overall. The power consumption isn't much more and the speaker is still really small, so these won't be a problem for us, but the vibration is a bigger downside. We will test to see how much the vibration will be with the speaker inside the baby and playing sounds at the expected volume. If it is too much, we can add dampening material to try to reduce it.



From our testing in sprint 1 we know that the DAC we use generates a staircase like signal. We think we can improve this signal using capacitors or a more complex filtration system which is what we will be looking into next sprint.

Conclusion

We are happy with the performance of the electromagnetic speaker because of its better sound quality with minimal downsides, and we will continue improving the system during the next sprint. For more information regarding the testing and research of speakers, see "Speaker research.docx".

2. Motion sensor module.

8.3 motion sensor hardware selection

During sprint 2, the group developers investigated deeply in two types of motion sensors, the Adafruit Precision NXP 9-DOF Breakout Board and the MPU6050 6-DoF Accelerometer and Gyro.

The project owner, Mr. Johan Korten, provided the group with the Adafruit Precision NXP 9-DOF Breakout Board, but after the investigation into this sensor board, the group found that there are two deficiencies:

a). There is no I2C address pin on this board.

b). Lack of sophisticated library to get steady and precise value of Eular angles of the board.

While the group also found three advantages of another IMU, the MPU6050 6-DoF Accelerometer and Gyro board:

a). There is the I2C Address pin: AD0.

b). Containing a digital motion processor which can generate quaternions directly.

c). Lots of sophisticated library to get steady and precise value of Eular angles of the board.

Based on reasons listed above, the group finally decided using the MPU6050 6-DoF Accelerometer and Gyro board as the motion sensor in this group.

8.3 algorithm design

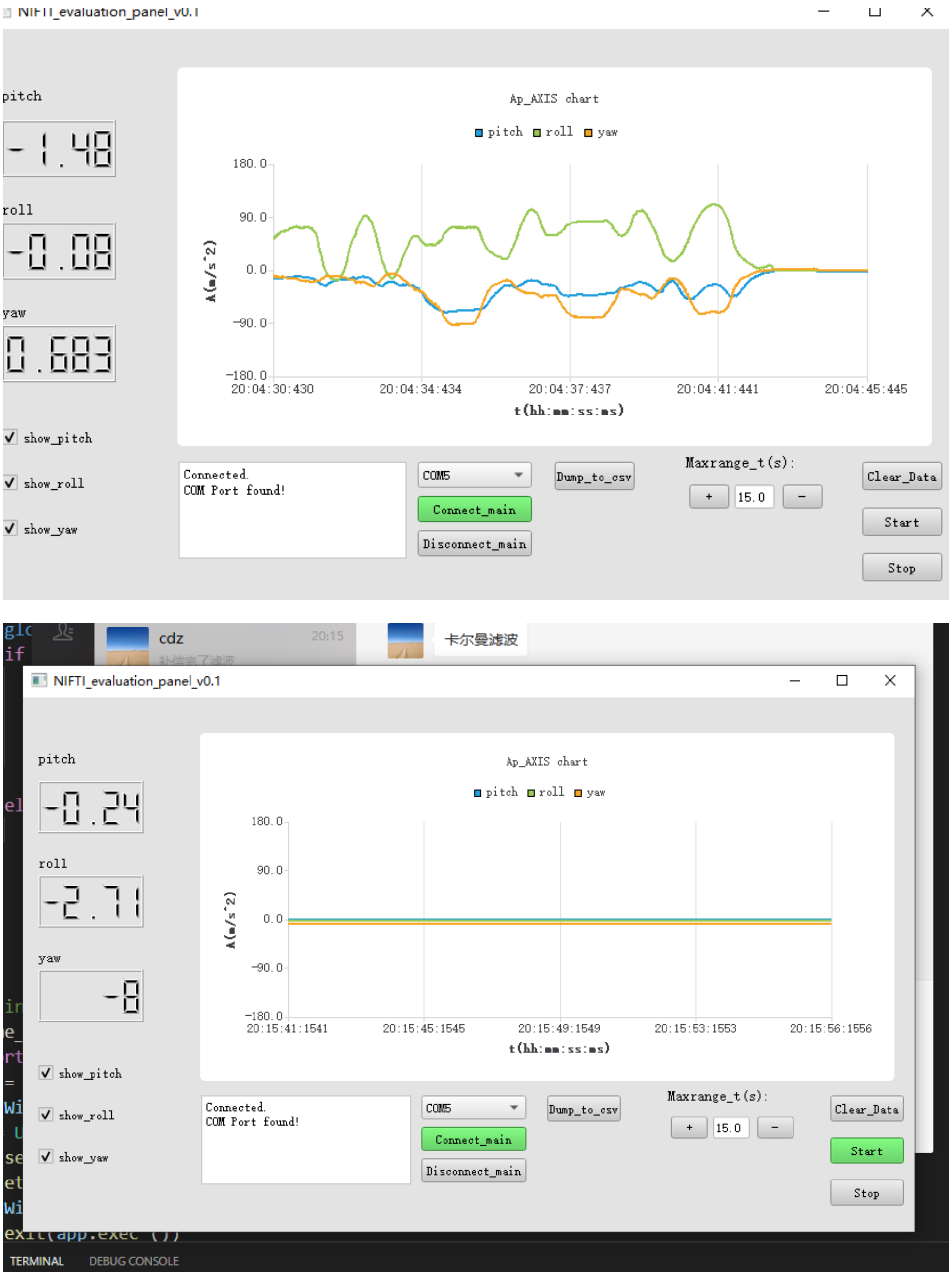
To get the steady and precise real-time Eular angles of the sensor board, the developers have to use filter algorithms and data fusion algorithms.

There were three methods of filter algorithm and data fusion:

a). Using complementary filter.

b). Using Kalman filter.

c). Getting Eular angles from the quaternions which generated by digital motion processor.



Software showing the Eular angles from the quaternions which generated by digital motion processor.

Since the Kalman filter algorithm is too complex, and other motion sensor boards might not have the digital motion processor, so finally the group decided to use complementary filter algorithm.

8.4 IPS Power supply and collaboration with S4

During sprint 2 the design of het power supply continued.

The design of the power supply has been further elaborated during sprint 2. This means the following:

a) Structure of the safety- & control switches circuitry (block 8, see figure X)
b) Finished schematic design of the 12V DC-DC converter
c) Finished schematic design of the 5V DC-DC converter

a. Structure of the safety- & control switches circuitry

The circuitry of block 8 (see figure X) contains the following elements:

-Fuel gauge IC to monitor the battery pack with following functions:
- State-Of-Charge (SOC)
- Time-To-Empty (TTE)
- State-Of-Health (SOH)

-Voltage sensing circuitry which is connected between the SAMD21 and the output voltage of each converter
-A fuse (5A), which is used as an additional layer of safety
-Three connectors
- Battery connector
- Two DC charging connector
- Serial communication and power out connector

-User Interface
- Error LEDs (i.e. 12V converter not working properly)
- Status LEDs (i.e. 12V converter turned on or battery low)
- Switches (Reset button, on/off switch for each converter and the total power supply)
- Prototype options (extra LEDs and switches for future options)

-USB connection to the SAMD21.
-A FET based switch, controlled by the SAMD21, which can turn on or off each converter
-A temperature sensor to prevent overheating

b. Finished schematic design of the 12V DC-DC converter

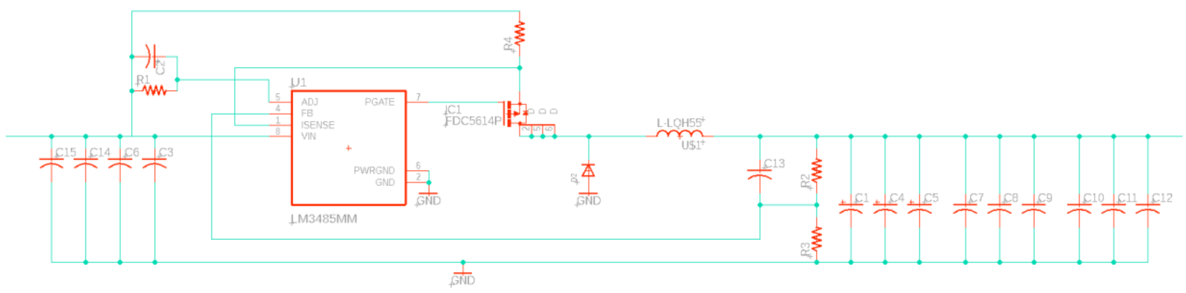


Figure 6: EAGLE Schematic of 12V Buck converter

This design is based on the TI WEBENCH Power Designer. The main input parameters are as follows:
- Input voltage: 12.8-16.8V, 14.8V nominal
- Output voltage: 12.00V
- Max continues current: 2.5A

- Switching frequency: <500KHz

This yielded over 100 possible designs. The controller IC is the main parameter on which the final decision has been based. The LM3485 is a Hysteretic PFET Buck Controller. This controller has been selected because of it's following features:

- This controller has a VSSOP package which is still solderable by hand by semi skilled labour
- Straightforward application circuit which doesn't require to many components
- Useful datasheet
- Available at all the big resellers (and of course not EOL)
- Efficiency around 93%
- Current limit protection
- Considerable low switching frequency (around 150KHz)

The Power Designer's design is only honoured partly. For example: Instead of two, nine output capacitors are used due to lower ESR and to filter more of the harmonic frequencies. Most of the resistor's SMD packages are switched from 0406 to 0805 to increase solderability. A gate resistor is added to reduce ringing since the length of the trace from the LM3485 to the PFET probably will be longer then desired by the original design.

c. s design of the 5V DC-DC converter

The 5V buck converter is also designed with the information from We Bench tool of Texas Instruments. For the power conversion between 14.8V as input to 5V as output, there are 4 types of buck converter ic, that is suitable for the power supply of this requirement.

Those 5 are:

- TPS40303
- LM25117
- TPS53819A
- LM25141

All of them have the efficiency above 90% and less switching frequency (near 300kHz), however TPS40303 has the less BOM count that this buck converter ic is chosen for implementation on the power supply board. The lesser the BOM count, the lesser the complexity of the technics, price and the more efficient it is. The suggested circuit on the We Bench is customized because some components are not available. After customization of the circuit, the circuit is designed in the Eagle. The final result of the electrical schematic is shown in figure … . This design is made to apply

The BOM-list, the datasheet of TPS40303 and the graphs of start-up and steady state of 5V buck converter are in the files ELT>ELT-IPS>Converter>5V.

- 5V_buck__steady_state.pdf, BOM-list and graphs related to 5v circuit and graph of steady state
- 5V_buck_start_up.pdf, BOM-list and graphs related to 5v circuit and graph of start up
- Tps40303.pdf, datasheet of TPS40303

This design is based on the TI WEBENCH Power Designer. The main input parameters are as follows:

- Input voltage: 12.8-16.8V, 14.8V nominal
- Output voltage: 5.00V
- Max continues current: 4A
- Switching frequency: <300KHz

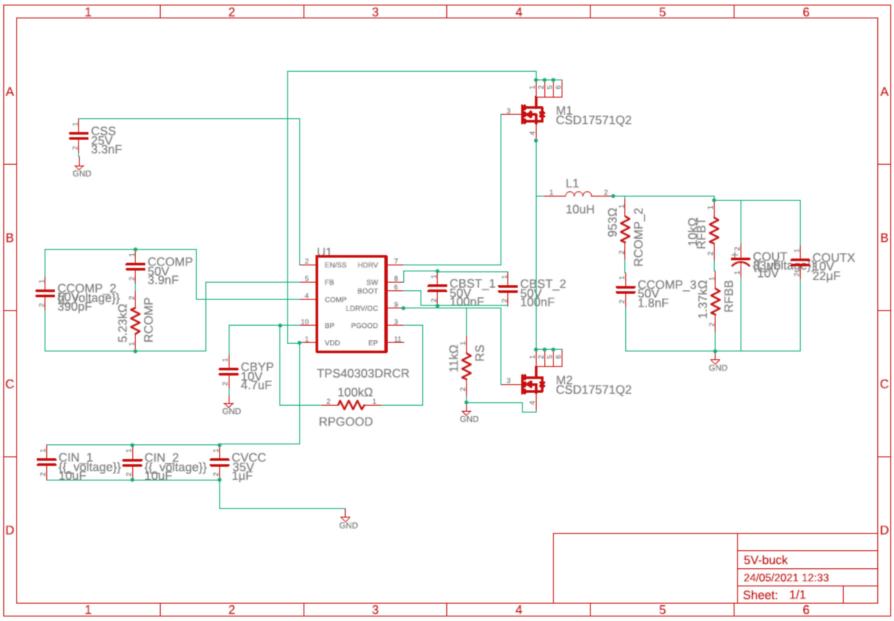


Figure 7: EAGLE Schematic of 5V Buck converter

Collaboration with S4

Last two weeks an S4 student, Kejsi, has to develop a converter of 3.3 V. We think that Kesji could be the part of our project if the design is bit similar to our design of 5V – and 12V buck converter. However, the final result of Kesji's design is big different to ours, because the idea differs from the ours. We have a standalone ic that controls buck converter, while the Kesji's buck converter is controlled by Atmega 328P. So, the collaboration of S4 student with S6 students won't take place, however there is contact to share the ideas for the improvement.

The vision from the product owner of buck converter is that the buck converter is controlled by SAMD21 of the duty cycle, however it is not efficient idea. SAMD21's processor will be overloaded with programs and it takes more storage capacity unnecessary. The efficient way to control the buck converter is to apply the ic to control buck converter stand

8.5 DESTEP and its meaning

In this chapter the DESTEP from Sterre Wouters will be summarised and explained what it means for the Infant life support simulation. First we take the six subjects and there most important information finding.

- Demographic – the population is growing, so more people more babies and the education level is growing. This means more nurses and doctor who need training in reanimation.
- Economic – lots of parts come from China and that's a threat. China becomes more second or first world country, with that the prices will rise. Also has China lots of the materials in the ground to make models, what if they decides to keep it for them self?
- Social – the infant needs to be in different colours to represent everyone in the Netherlands, also is gender neutral an option in the future.
- Technologic – technology is constantly moving forwards and who knows what is possible in five years with the baby. That's why the baby must be designed modular so models can be removed and replaced without making a complete new baby.

- Ecological – here is overlap with technology because making a product modular is better for the environment. Also choosing materials that have a long lifespan and you can find in multiple places in the world. Creating a better world starts with the product design.
- Politics – subsidy can be earn if the product/project has positive impact on the society. In a later stadium patent must be taken to protect it.

What does this a mean for the Infant life support simulation?

There are a couple threats and opportunities that are clear and can be used for a business model. Below we will show the opportunities and how the you earn revenue true it.

Opportunities	**How to earn revenue**
Higher education level	More who are interested to learn and need an infant life support simulation to train what means More sales.
Multi cultural and gender neutral	The selection becomes bigger to fur fill everyone’s needs. So more infant will be sold to make everyone happy and no one is offended
Fast growing technology	If new technology is available you can replace the old parts for new ones and make the infant better, but of course for a price
Designing for a better world	If the baby is more eco friendly the change to earn a subsidy and that means more money for development and manufacturing

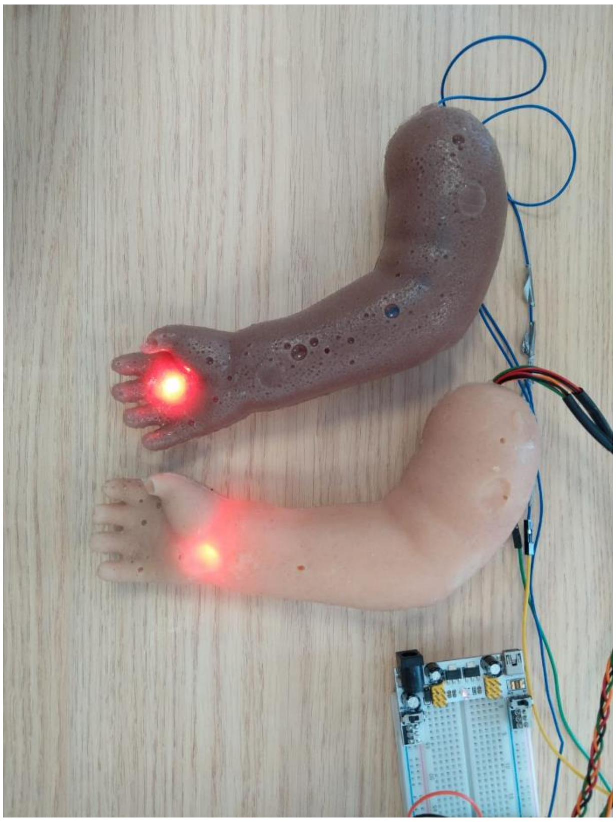
9. Sprint 3

9.1 the improvement of the arm

1. The start of sprint three was hectic, with bad communication with the fablab and a failed print.
2. The IPS student had prepared a new LED for in the arm, when the inside of the arm was printed in flexible material the LEDs were glued to the print.

3. The new arm was a new opportunity to try a new skin colour, this time the darkest pigment was used called hazelnut brown.
4. Prior to pouring the arm directly a few new swatches were made to make sure the right combination of pigment and fibbers were used.
5. Although the pouring of the new arm went smoothly the result was less than ideal, the silicone skin didn’t in case the whole inside of the arm, showing the whole LED. The brown

skin looked sickly and just not right and there were far to many air bubbles making the arm look like it has a disease.



6. When it became clear there wasn't enough time to make the silicone leg the focus of the IDE students turned to the development of the app.
7. This is the last sprint done by our project group. That is why we want to provide a clear report so that it is clear to the next group what we have done.
8. We have also given a number of options that they can work with and start right away. We did this because it took us a very long time before we started something.
9. We have been working on the silicone of the Infant Life Simulator. We have explained how we did this step by step in a document.

9.2 detail engineering of electrical design for power supply

As stated in sprint 2, block 8 in figure 5 must contain the following elements:

1. -Fuel gauge IC
2. -Voltage sensing circuitry converter
3. -Fusing
4. -Connectors
5. -User Interface
6. -USB connection to the SAMD21.
7. -A FET based switch
8. -Thermal protection

Not all points will be discussed in this report. More details are given in the Eagle files. The circuitry is now prepared for a 3.3V converter as well. The circuits of the 3.3V converter are not designed yet.

Fuel gauge IC: The design of the fuel gauge circuitry will not be done in this period duo to lack of time. Recommended is to use a fuel gauge IC that uses a combination of voltage sensing and coulomb counting. Only voltage sensing is not sufficient for this scenario due to lack of accuracy. The IC must have multi cell option (there are workarounds, but why bother if there are plenty of IC's available with this specification). The IC must also be able to be placed on the host-side instead of the battery side. Maxim Semiconductors has nice tutorials and great documentation, their Model Gauge m5 series should be suitable. The TI BQ34110 Multi-Chemistry CEDV Battery Gas Gauge could be considered as well.

Voltage sensing: The voltage sensing is easily done by connecting the output of each converter to a voltage divider which feeds back this voltage to an analogue input on the SAMD21.

A FET based switch: The SAMD21 must be able to turn on or off the SMPS. Most certainly since the 12V converter has no use yet. The idling current would make the system less efficient. An extra layer of safety is introduced since the output voltage of the converters are fed back to the SAMD21.

In this case it's be more convenient to use a P FET instead of a N FET. A N FET requires, normally speaking, a Vgs of 10V to 'turn on'. This would be a problem since it's desired to connect the load of the FET (the actual convert) to the source. This would mean that Vg, relative to ground, would be 10V plus the battery voltage. Of course there are workaround like a bootstrap circuit, but this would involve extra switching losses.

The following circuit is designed (figure 9):

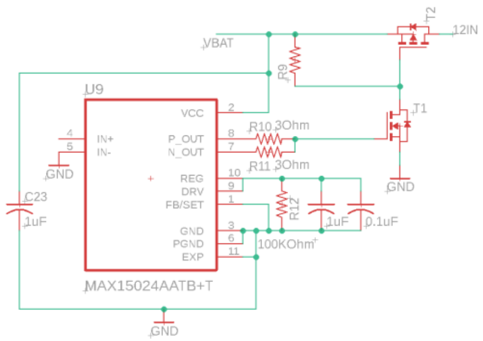


Figure 9: P FET based switch

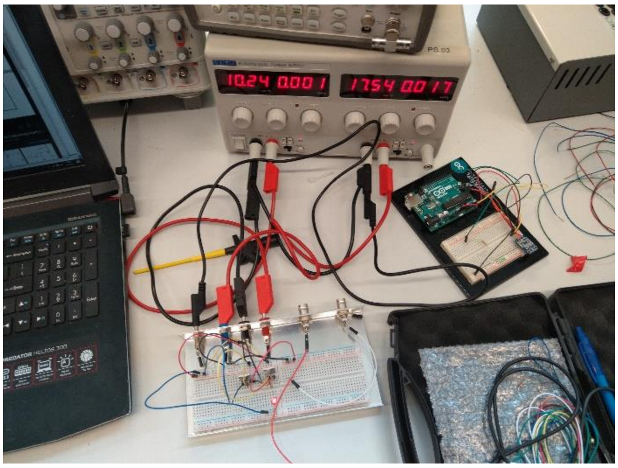


Figure 8: P FET based switch, test circuit

The circuit's principle is tested without the MOSFET driver (figure 8). The P FET (T2) requires a Vgs between -2V and -4V to 'turn on'. Logic input IN+ controls the switch. Let's consider the following situation: VBAT = 16.8V. IN+ = low so Vgs@T1=0V. In this case Vgs@T2 steady state is 0V because there is no potential difference between Vg@T2 and VBAT. When IN+ is set to high, Vgs@T1 will be 10V which turns on T1. Now the gate of T2 is connected through a low Ohmic path to ground and Vg@T2 to ground will therefore be roughly equal to 0V. Therefore Vgs@T2 is -16.8V and will 'turn on'.

The gate driver is added and used as a level shifter to supply the gate of T1 with sufficient voltage and current. The logic 3.3V from the SAMD21 is a low voltage and could cause trouble turning on a N FET. Also the use of a FET driver lowers the stress on the microcontroller by reducing peak current from the digital output. It's important that the P FET is able to handle a gate voltage of at least + AND – 25V. Most are rated for +-20V, which will work but will put stress on the P FET.

Thermal protection

Thermal protection is not added to the circuit yet. Some similar circuit as shown in figure 10 could be used for this purpose (Learning about Electronics, 2013).

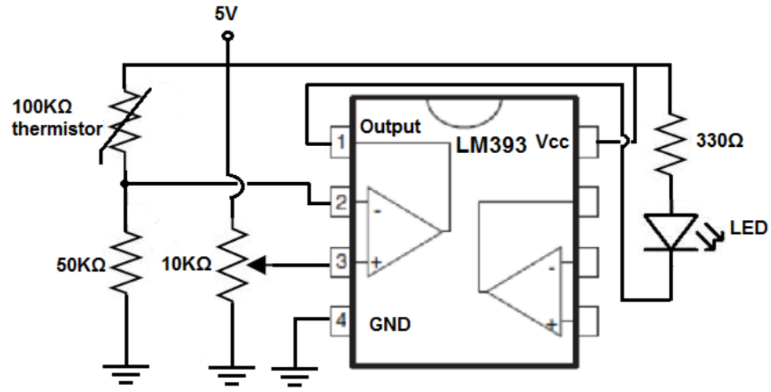


Figure 10: NTC based thermal protection

The 330Ω and the LED will be, of course, replaced by a connection to the SAMD21.

For calibration a thermal imaging camera should be used to monitor the heat generated by the SMPS's after running for a while. The circuit could be placed on multiple points on the board. I.e. in proximity to all converters.

5V buck converter

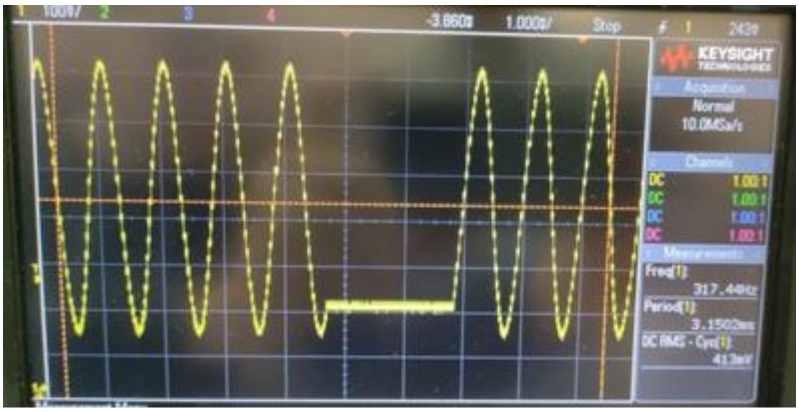
In this sprint, the 5V buck converter is adjusted from the previous sprint. It is needed because the output caps (as ceramic as electrolytic) have very high ESR, which will cause lower efficiency and so the poorer transient response. The solution is to use the output caps (for this converter electrolytic as ceramic) with low ESR. In the schematic, there is three electrolytic caps and three ceramic caps drawn. The recommended value for caps, see the We Bench tool datasheet (ELT>ELT-IPS>Converter>5V>5V_Buck_Startup_V3.pdf)

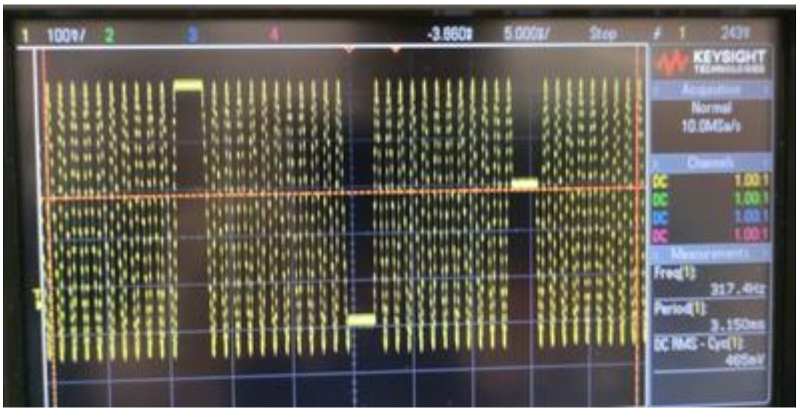
The search to electrolytic caps with low ESR is hard (while the question is still what value is low ESR?), so it is important that this circuit is tested/simulated before it is assembled (also for 12V buck converter). The output voltage (5V) should not be unstable and unstable voltage could damage other part systems. In the schematics, there is more technical explanation about the requirements for power supply in the side-line/footnote. So please read the electrical schematic in …

9.3 Audio feedback system and motion detection communication

Audio feedback

Further research into what could be causing poor audio quality showed us a disturbance in the outgoing signal. Around every 12ms the signal would have a hiccup and the output would remain at the same amplitude for about 2ms. This is visible in the two following images.





The reason for this occurring is either that the Arduino prioritises doing something else over sending the audio signal or the audio file is being read too slowly causing the Arduino to not know what to send next and hang for a while whilst waiting for new information.

Both of these issues are a result of how the library reads the SD card and operates the DAC.

The audio library we used was the “Zebroid” audio library, which was the only one we could find that was able to perform the task of reading the SD card and playing audio on the Feather M0 board. After looking into the inner workings of the library it wasn’t immediately clear what was causing the hiccup. We found an example using a different library that was able to play audio consecutively without any hiccups, but this was using audio samples stored in the program memory of the Arduino. In the end we decided to leave the old library behind and expand on the example that we know works by implementing the reading of the SD card into it.

Conclusion:

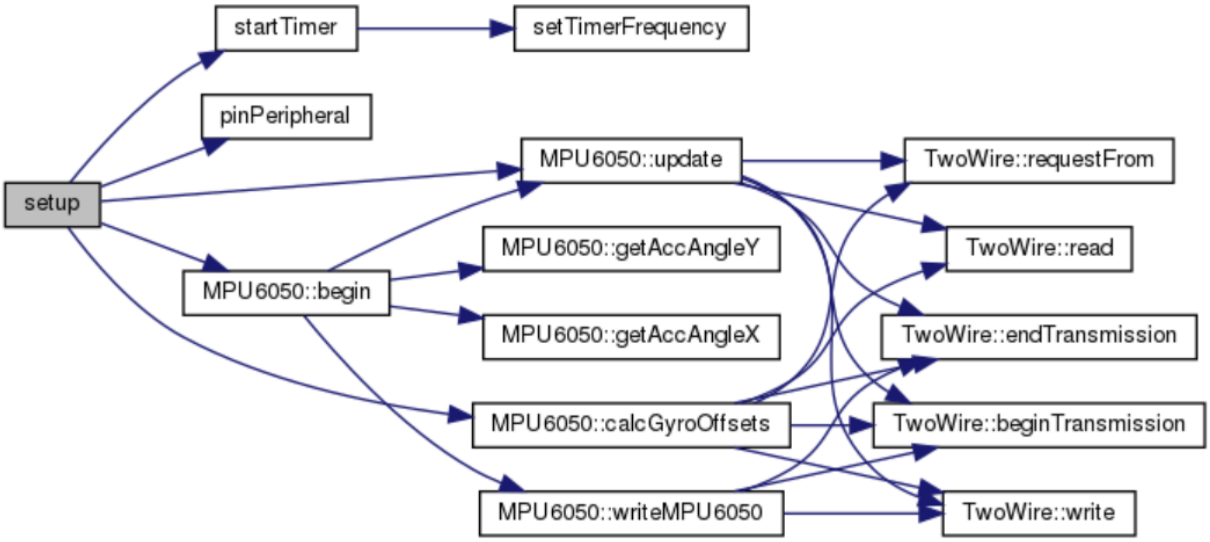
The old library was causing issues which effected the audio quality. Using a different library with a bit of customization will resolve this problem and give us the audio quality that we want.

For more information regarding the testing and research of speakers, see “Speaker research.docx”.
motion sensor module

Here is the software implementation of the motion sensor module.

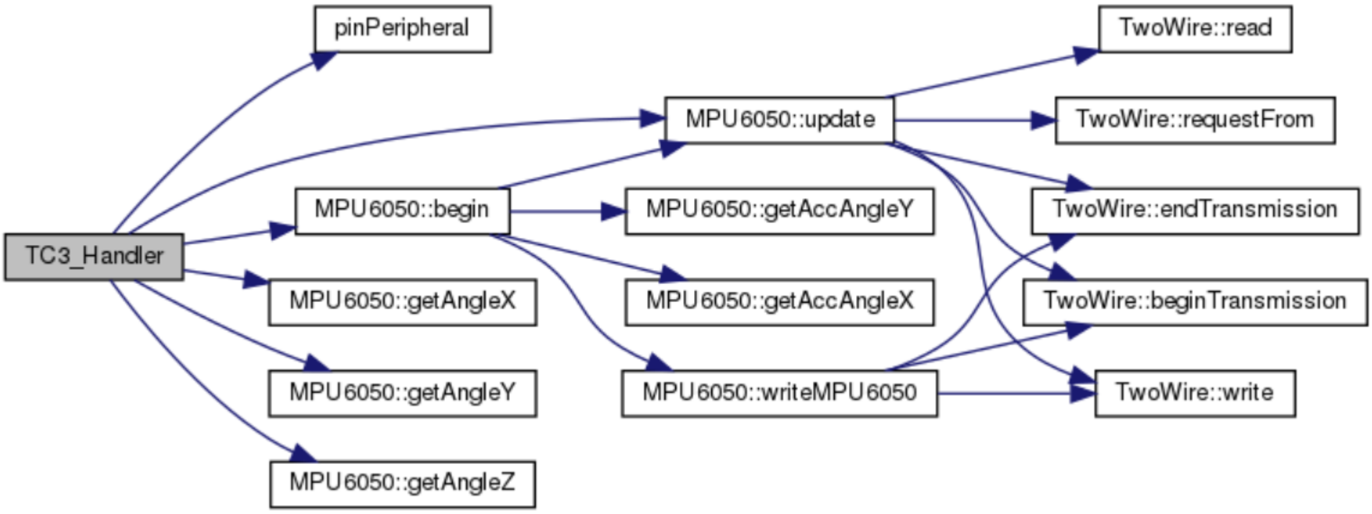
In the final software for the motion sensor module, we use timer to generate interrupt, and calculate the angle differences between two motion sensors in the interrupt handler routine.

In the setup function, we initialize the MCU peripherals and the motion sensors.



Then we setup the timer

Finally, the timer interrupt handler routine:



10 Guideline IEM student

In this chapter a guideline for the S6 project Infant life support simulation will be summarised. The full document will be in Dutch and can be found under the name IEM-C-Handleiding. The idea to make a guideline come when reflected back to the project. The start was slow and chaotic, we simply did not know how to start. It took us four to five weeks to start sprint 0 and start the project. Also for me the IEM student it was hard to found my roll and tasks. Below the roll of IEM student will be shown and in the IEM-C-Handleiding file it will be explained.

- Scrum master
- Planner
- HRM manager
- Business researcher
- Agile and scrum expert

11 Letter of recommendation

11.1 IDE

Aan het begin van het project hadden wij een lijst gemaakt met onderwerpen waaraan gewerkt zou kunnen worden. Aan een aantal van deze onderwerpen zijn wij niet aan toegekomen of hebben wij nog niet helemaal af kunnen ronden. Dus het is aan jullie om hierop voort te bouwen.

Niet afgeronde onderwerpen

<u>Ledjes</u>
<u>Het meest hebben wij ons bezig gehouden met de ledjes in de siliconen te verwerken. Hiervoor zijn wij alleen bezig geweest met de ledjes in de handen en voeten.</u>
<u>Er zou later ook nog gekeken kunnen worden naar rode ledjes voor de wangen en blauwe voor de mond. (Deze moeten natuurlijk ook andere kleuren kunnen zijn om andere ziektes uit te beelden zoals geel en wittig.)</u>

<u>Huidtinten</u>

Wij hebben ons ook gefocust met het uiterlijk van de huid. Ons doel was om deze zo echt mogelijk eruit te laten zien. Hier zouden vooral bij de huidtinten nog veel verbeteringen in gemaakt kunnen worden. Ons doel was om drie verschillende huidtinten te maken: blank, getint en donker. De blanke kleur is goed gelukt, echter is de donkere kleur minder mooi uitgepakt. Deze heeft een grijze ondertoon die niet realistisch uitziet. Ook zijn wij er niet in dit project aan toe gekomen om de getinte huid uit te werken.

<u>Aderen</u>

Omdat wij bij de blanke arm erachter kwamen dat de kabels een beetje te zien zijn door de huid heen, lieten wij de kabels als aderen over de kern lopen bij de donkere arm, daarnaast zijn de kabels aangepast dat deze blauw zijn van kleur. Hierdoor ziet de baby er realistischer uit. Echter ontdekte wij dat deze aderen niet bij de donkere huid doorschenen en dat deze functie dus alleen nut heeft bij de blanke huid. Of dit ook zo geld bij de getinte huid hebben wij niet kunnen testen.

Niet aan toe gekomen onderwerpen

Ribben

Wij hadden aan het begin van het project gebrainstormd over het verbeteren van de ribben. Om de ervaring van het breken van de ribben realistischer te maken moet het ontwerp hiervan aangepast worden. De huidige ribben bestaan uit verend schuim. Hierbij voel je dus geen breuken. Wij zijn er in dit project niet aan toe gekomen om dit onderwerp verder uit te werken.

Details

Het realistische uiterlijk van de baby was een erg belangrijk onderwerp voor ons. Om dit een stap verder te nemen wouden wij zelfs haren, nagels en wimpers toevoegen. Ook hadden wij gebrainstormd over toevoegen van een kont d.m.v. siliconen. Echter zijn wij ook hier niet aan toegekomen omdat het realistische uiterlijk van de siliconen zelf meer tijd kostte dan wij verwacht hadden.

Opladen

Een onderwerp waar in het volgende semester aan gewerkt kan worden is het opladen van de simulator. Dit gebeurt door een drop in oplader (vergelijkbaar met earpod oplader) , de beste locatie om dit systeem in te bouwen is op de rug van de baby. Om connectie te kunnen maken met de rug en matras van de baby mogen er geen kleren tussen zitten. De kleren van de baby moeten hiervoor aangepast worden. Op de rug van de baby moet er een gat in de kleren komen. Om te zorgen dat dit gat niet verschuift en alsnog de connectie verbreekt kan het gat met klittenband of door een ander middel op de rug vastgemaakt worden waardoor het niet meer kan verschuiven.

Om de baby goed contact met het contactpunt te laten maken moet deze op de matras liggen. De connectie punten moeten makkelijk verbinding kunnen maken met de oplaadpunten dit kan door het connectie punt magnetisch maken. Om te zorgen dat de baby op zijn plek blijft liggen kan er een uitholling van de baby's vorm in de matras verwerkt worden.

Daarnaast moet er een batterij pack in de baby verwerkt worden hier moet onderzocht worden waar dit kan en waar er ruimte is. Dit brengt ook gewicht met zich mee dus er moet berekend worden hoe zwaar dat dan is en of dat nog in een lijn staat met het gewicht van een echte baby.

Er moet onderzocht worden of er een intern of een extern bedieningspaneel aanwezig moet zijn of er moet een extra functie komen op de app om deze weer te geven. Hierdoor kan de gebruiker duidelijk zien dat de baby opgeladen wordt. Dit kan door middel van een ledje laten lichtgeven op het bedieningspaneel van de baby.

Stappenplan: Siliconen arm

1. Scannen

1. Maak het armpje los van de babypop
2. Maak een afspraak met Ruth, om de 3D scanner te gebruiken
3. Leg het armpje onder de scanner
4. Pas de instellingen zo aan, dat het hele armpje gescand kan worden (het makkelijkste is om 2 scans te maken en deze op elkaar uit te lijnen)

5. Ruth kan deze 2 scans op elkaar uitlijnen

2. Voorbereiden

1. De scan van Ruth kan geprint worden met een 3D printer
2. De 3D geprinte arm heeft nog wat voorbereiding nodig, voordat de mal gemaakt kan worden
3. Deze moet ingespoten worden met vloeibare plamuurspray
4. Als dit droog is, moet deze fijn geschuurd worden, zodat de groeven dicht komen te zitten
5. Nu is het armpje glad en kan de mal gemaakt worden

3. Box maken

1. Ga naar de website: www.makercase.nl
2. Maak hier een box met de juiste afmeting
3. Kies hoeveel klikvingers je wil hebben
4. Sla het document op als DXF
5. Dit document kan daarna gebruikt worden om de bak te laten laseren
6. Lijm deze bak in elkaar en kit de randen dicht

4. Mal maken

1. Vraag aan Johan of Ruth om siliconen te bestellen voor de mal
2. Pak de bak erbij en vul deze voor de helft met klei
3. Leg het 3D armpje tot de helft in de klei
4. Vul de andere helft met siliconen
5. Laat dit goed drogen en verwijder de bak
6. Stop het siliconen gedeelte weer terug in de bak en leg het armpje er weer terug in
7. Vul nu de andere helft met siliconen zorg wel voor een ontluchting gat en opkomer, dit deden wij door twee staven taps aan de 3D vorm te plakken
8. Laat dit weer goed drogen en verwijder de bak
9. De mal is nu klaar voor gebruik!

5. Arm maken

1. Van tevoren is het handig dat er huid swatches gemaakt worden, zodat je zeker weet wat de kleur wordt
2. Om de arm te kunnen maken, is er ook een binnen armpje nodig
3. Dit is dezelfde scan van de arm, maar dan 10 cm kleiner
4. Prik 2/3 kleine pinnetjes van 5cm in de onderkant en bovenkant van de mal, zodat het binnen armpje goed gepositioneerd is (hier moet nog een andere oplossing voor komen)
5. Vul de onderste helft van de mal met siliconen
6. Leg het binnen armpje hierin en vul vervolgens de bovenste helft van de mal met siliconen
7. Leg de bovenkant erop en vul eventueel nog bij via de gaten in de mal
8. Halfuurtje laten drogen en het armpje is klaar

Tips

Om nog betere resultaten te krijgen, is het handig om nog naar de volgende punten te kijken en verbeteren. Hier hadden wij helaas geen tijd meer voor.

1. Huid swatches kunnen gemaakt worden in bekertjes (dit moeten dunne laagjes zijn) *5.1*

2. Binnen armpje nog kleiner schalen (onderarm moet dan langer gemaakt worden, zodat de ledjes in de hand komen) *5.3*
3. Andere oplossing bedenken voor de pinnetjes *5.4*
4. Werk met een vacuüm machine om ervoor te zorgen dat de luchtbelletjes verdwijnen
5. Goed communiceren met Ruth, want het kost veel tijd en moeite om iets geprint te krijgen door eventuele drukte of materiaal dat er niet is.
6. Een andere mal proberen?
7. Werk goed samen met IPS voor de ledjes

Heel veel succes ermee!

11.2 ELT-IPS

Oplaadfunctie voor de infant life support simulator

In het hele project is er uitgezocht hoe de simulator opgeladen kan worden zonder dat er de bedraden verbinding is tussen de simulator en de oplaadpunt. De kabel kan storend zijn voor de verpleegkundige tijdens de training. Uiteindelijk is oplossing gevonden door samen te werken met IPO en productowner. De oplossing is de drop in charging vergelijkbaar met earpod.

Wat er verder moet gebeuren:

- Het ontwerpen, realiseren en testen van de drop-in connectoren in een matrasje en aan de rug van de simulator
- Daarna testen van de oplaadfunctie of het werk goed doet zoals de wens van de productowner en dat de batterij goed is opgeladen binnen 5u.

Power supply voor de infant life support simulator

Er moeten nog wat gebeuren bij de power supply. De afgeronde zaken zijn hieronder weergegeven:

- Architectuurschema van de power supply (zie schema …).
- Ontwerpen van 5V en 12V buck converters in elektrische schema.
- Ontwerp van veiligheidscircuit voor de power supply in elektrische schema.
- Ontwerp van voltmeter in elektrische schema.
- Ontwerpen van interfaces (ledjes, switches etc) in elektrische schema.

De zaken die af moeten zijn:

- PCB ontwerpen van powersupply board onder andere buck-converters, voltmeter, connectoren, veiligheid circuitjes etc.
- Testen van het elektrische circuit volgens het ontwerp. Het is belangrijk punt is de waarde van uitgangscapacitor, zie de uitleg in sprint 3 van ELT IPS in het verslag.
- Realiseren en testen van powersupply board.
- Onderzoeken en testen van BMS.
- Extra opties bedenken voor de veiligheid en beveiligen voor power supply.
- Zie ook in elektrische schema's

11.3 ELT-ESE

Communication between two microcontrollers

The mainboard is Nano 33 BLE(nrf52), the control board and the sensor board are all feather M0(SAMD21). Group developers can only use the mainboard as the I2C master to send information to slave and set the feather M0 as the I2C slave to read information from master.

The group developers can not set the feather M0 as the master to communicate with other MCUs by using I2C. So this is the one work left for following students.

Audio feedback system

The audio feedback system has some finishing touches that need to be done. The working parts are:

- Amplifier
- Speaker
- Basic audio playing from Feather M0

What still needs to be done:

- Playing audio from SD card
- I2C communication with main board

LED’s

One of the main forms of feedback in the baby are the LED’s. We choose the neopixel LED’s for their ease in use and versatility. These LED’s work and can change in brightness and colour but there is still work left in finding all the places they need to be implemented. And they also need to communicate with the main board so they can respond to everything happening with the baby.

Other tasks

There are plenty of tasks that we didn’t get our hands on during this project. These are:

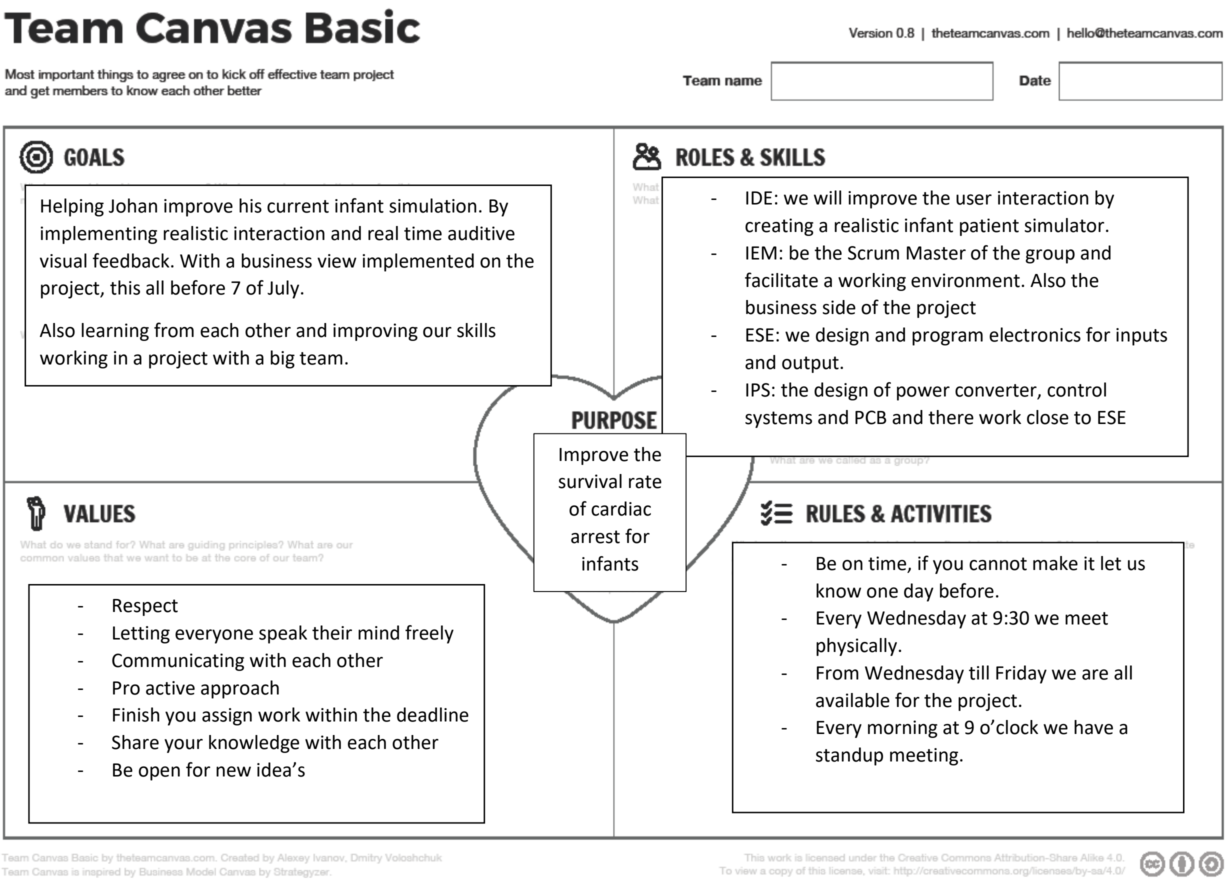
- Implement heartbeat feedback to the user in groin, ankles and wrists
- Improve feedback given through the phone app
- Improve measuring of chest compression depth
- Improvements to the lung system
- Improve Bluetooth communication with the phone
- Improve logging of feedback results with Raspberry over WIFI
- Improve data communication between sensor modules
- Implementing body temperature features in the infant simulator.
- Improve the communication between MCU and Raspberry Pi
- Implementing of moving nostril
- Making it possible to tube the baby
- Simulate spit up when there is too much air in the stomach
- Sensor that confirms a correct positioned thermal probe. (Rectum)
- Wireless connection between monitoring box and infant simulator

12 rules and contract

In the Attachments 2 you can find the contact with rules the project group agreed to, also the contract is signed.

Attachment

Attachment 1



Team Canvas Basic

Version 0.8 | theteamcanvas.com | hello@theteamcanvas.com

Most important things to agree on to kick off effective team project and get members to know each other better

Team name

Date

GOALS

Helping Johan improve his current infant simulation. By implementing realistic interaction and real time auditive visual feedback. With a business view implemented on the project, this all before 7 of July.

Also learning from each other and improving our skills working in a project with a big team.

ROLES & SKILLS

- IDE: we will improve the user interaction by creating a realistic infant patient simulator.
- IEM: be the Scrum Master of the group and facilitate a working environment. Also the business side of the project
- ESE: we design and program electronics for inputs and output.
- IPS: the design of power converter, control systems and PCB and there work close to ESE

PURPOSE

Improve the survival rate of cardiac arrest for infants

VALUES

What do we stand for? What are guiding principles? What are our common values that we want to be at the core of our team?

- Respect
- Letting everyone speak their mind freely
- Communicating with each other
- Pro active approach
- Finish you assign work within the deadline
- Share your knowledge with each other
- Be open for new idea's

RULES & ACTIVITIES

- Be on time, if you cannot make it let us know one day before.
- Every Wednesday at 9:30 we meet physically.
- From Wednesday till Friday we are all available for the project.
- Every morning at 9 o'clock we have a standup meeting.

Team Canvas Basic by theteamcanvas.com. Created by Alexey Ivanov, Dmitry Voloshchuk
Team Canvas is inspired by Business Model Canvas by Strategyzer.

Attachment 2

Volgende afspraken zijn van kracht gedurende de S6 project periode van Februari 2021 t/m juli 2021.

1. Wees op tijd. Kun je niet op de afgesproken tijd aanwezig zijn? Geef dit dan voor 00:00 aan in de project Whatsapp-groep de dag voor de meeting.

Heb je niet tijdig aangegeven dat je er niet op tijd kan zijn? Dan heeft dit de volgende consequenties als je 5+ minuten te laat bent:

a. Traktatie

b. Milde waarschuwing (een streepje op je naam)

2. Je moet je werk af hebben voor de afgesproken deadlines. Heb je je werk niet af op of voor de afgesproken deadline heeft dat de volgende consequentie: a. Officiële waarschuwing (twee streepjes op je naam)

3. Toon voldoende inzet gedurende het hele project. Dit is moeilijk meetbaar, aan de volgende punten zal aandacht besteed worden om dit te controleren:

a. Aanwezigheid bij meetings en je participatie gedurende de meetings (dus ook je inbreng).

b. Reactie op berichten/oproepen in de Whatsapp-groep, op e-mails, of op Teams en discord etc.

c. Actief bezig met de scrummethode en het stellen van doelen voor de sprintjes.

d. Voldoen aan de deadlines.

4. Elke *online* werkdag om 09:00 stand-up meeting. In deze meeting wordt de voortgang gemeten en worden afspraken gemaakt over de planning.

5. Er wordt verwacht dat je elke woensdag, donderdag en vrijdag gedurende de projectperiode beschikbaar bent van 9:00-17:00 om aan het project te werken. Mocht je andere activiteiten hebben gedurende deze tijden, laat dan het volgende weten in de stand-up meeting:

a. Gedurende welk tijdsbestek je afwezig bent.

b. Of je bereikbaar bent gedurende je afwezigheid.

c. Of het projectafspraken in de weg zit. Zo ja, wat ga je er dan aan doen zodat dit niet het geval is.

6. Elke week (minstens) eenmaal fysiek afspreken op de HAN Arnhem. Bij voorkeur elke woensdag, hier kan van afgeweken worden als er andere afspraken gemaakt worden (bv. door COVID-19 of workshops etc.). Bij een *fysieke* werkdag *op school* start de stand-up om 9:15.

De consequenties van een streepje op je naam zijn n.t.b. en worden opgenomen in de aanwezigheid lijst. Ik ga akkoord met de bovengenoemde afspraken:

Voor- en Achternaam: ……………………………………………………….

Datum en handtekening :……………………………………………………..

Attachment 3

1. Bedreiging van nieuwe toetreders	
Is het hebben van schaalvoordelen niet belangrijk in deze tak van	Niet echt
Is er een klein kapitaal nodig om tot uw markt toe te treden?	In zekere mate
Is de kans op tegenacties van bestaande aanbieders klein?	Neutraal
Kunnen toetreders gebruik maken van bestaande distributiekanalen?	Zeker
Hebben toetreders toegang tot bestaande of nieuwe technologieën?	Niet echt
Zijn klanten weinig loyaal aan merken?	Zeker
Kunnen toetreders ook over (overheids-)subsidies beschikken?	Neutraal
Bestaan er geen hoge drempels om van leverancier te wisselen?	Niet echt

2. Onderhandelingsmacht van Afnemers (handel / gebruiker)	
Is er sprake van één of enkele grote afnemers(groepen)?	Niet echt
Zijn de producten of diensten homogeen van aard (weinig	Geheel niet
Worden de afnemers van uw markt met lage marges geconfronteerd?	Geheel niet
Speelt kwaliteit een geringe rol in de koopbeslissingen van uw afnemers?	Zeker
Hebben de afnemers van uw markt toegang tot informatie (hoge mate van transparantie) over hun leveranciers en hun aanbod?	Niet echt
Is de kans op verticale integratie aanwezig, bijvoorbeeld handel wordt ook producent?	In zekere mate
Hebben afnemers eigen (huis-)merken en toegang tot (internationale) productiebronnen? Hebben zij ook veel kennis van de bedrijfskolom?	Geheel niet
Is de onderlinge concurrentie hoog tussen afnemers / handel?	Neutraal

3. Onderhandelingsmacht van Leveranciers	
Wordt de bedrijfstak gedomineerd door een enkele leverancier of door een geconcentreerde groep van leveranciers?	In zekere mate
Zijn de merken van leveranciers 'gewild' binnen uw markt?	In zekere mate
Wordt de productiecapaciteit van de leveranciers in hoge mate benut? Dus er is veel vraag.	Neutraal
Leveren leveranciers een belangrijke bijdrage aan de kwaliteit / bewerking / innovatie van producten binnen uw markt?	Zeker
Worden de leveranciers van uw markt geconfronteerd met lage marges?	Niet echt
Treedt de overheid ook op als leverancier?	Geheel niet
Zijn de leveranciers innovatief en hebben zij veel marktkennis?	Zeker
Leveren zij strategische producten (Kraljic) en weinig routine producten?	Neutraal

4. Bedreiging van Substituutproducten of -diensten	
Is de functionaliteit van de substituten beter/uitgebreider dan de bestaande producten/diensten?	In zekere mate
Steekt de prijs / prestatie verhouding van de substituten gunstig af met die bestaande producten? Bijvoorbeeld lagere 'total costs of	In zekere mate
Is het voor de afnemers gemakkelijk om over te stappen op substituten?	Neutraal
Zijn substituten winstgevender en stellen leveranciers zich agressief op?	Niet echt
Komen er steeds meer acceptabele alternatieven, imitaties, plagiaten op de markt?	Niet echt
Zijn/komen er alternatieve technologieën, modellen of materialen op de markt?	Neutraal
Zijn/komen er alternatieve distributiewijzen beschikbaar, zoals internet, downloads?	Niet echt
Is de productlevenscyclus kort of wordt deze korter én is het aandeel nieuwe producten groot?	Niet echt

5. Rivaliteit tussen bestaande Concurrenten	
Is er sprake van een niet of nauwelijks groeiende marktsituatie?	In zekere mate
Zijn de producten/diensten op uw markt homogeen van aard <u>en</u> worden er weinig complementaire producten aangeboden?	In zekere mate
Zijn er veel bedrijven met dezelfde grootte en gelijke	Niet echt
Zijn uittredingsbarrières hoog? (moeilijk om activiteiten te staken)?	Neutraal
Ontbreken er strategische relaties (samenwerkingsverbanden) tussen concurrenten?	Niet echt
Is de markt al internationaal gericht, dus nieuwe toetreders hebben zich recent al gemeld?	In zekere mate
Neemt de stroom van goedkope alternatieven, imitaties, plagiaten toe?	Niet echt
Zijn de aanbieders volume-gericht en minder gericht op winstmarge?	Niet echt

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