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Revised Project Design

# 1 Introduction

## 1.1 Project statement

The project is about designing a milk flow meter to help mothers track how much volume of milk they feed their babies. Along with the breast flow meter, we are also building a mobile App in which the data will be sent to real time and display the statistic and volume of milk to the mother.

## 1.2 Purpose

This project is meant to be beneficial to mothers who are not sure how much is being fed to their child.  Its purpose is to prevent over or under feeding of infants.

## 1.3 Goals

The meter must be able to measure milk while NOT hindering the feeding process of the mother and child.  Another goal is to build a mobile application that can display and store data that is read from the breast meter real time. We plan to use light sensors, therefore our goal is detect the voltage across the photodiodes to measure the flow of milk.

# 2 Deliverables

A combination of accurate hardware and software implementation is necessary to have a full system to track the amount of milk.

The hardware needs to have efficient sensors to track the flow and be connected to a bluetooth component to send data to mobile.

The software must compute data efficiently and accurately so that data sent in bits is well converted into volume of milk to make it user friendly.

# 3 Design

The plan to test the software is to create some fake data through a costumed bluetooth handler using ps4 controller and keep sending data to mobile app. In that test we will mainly be observing the progress bar and test each breastfeeding session due to its high importance in the project. The next thing will be to test user cases such as how logging in with facebook integration and store data in phone memory.

The plan to test the hardware is to use formula milk then run some test and observe data by connecting the potential device to a computer via bluetooth.

The plan to test the whole system will be to integrate the software and hardware and using formula milk to test how accurate is the real time collection of data in the mobile app.

## 3.1 System specifications

-The system is supposed to be able handle more than one user which can be the mother, dad and other family members.

- The device must as small as possible and with wireless charging capability if possible

- The mobile app must make mothers recommendations on how they are supposed to feed their kids based on statistical data.

-The mobile must use some types of artificial intelligence to notify mom of when and how much their baby is full.

-The system must be childproof.

- The system must have no chocking hazard at anytime

- The System must be user friendly.

### 3.1.1 Non-functional

The design should not interfere in the breastfeeding process because it should measure the milk that is naturally coming out of the breast. The design should not be a choking hazard to the child being fed. The design should be rechargeable and washable for reuse.

### 3.1.2 Functional

The design should display the total volume of breast milk fed in a mobile device when breastfeeding is complete. The design should measure flow in real time, but displaying this flow in real time is not necessary. The app design should store data of total volume fed for a child that was fed.

## 3.2 PROPOSED DESIGN/METHOD

Our team has decided to go create a light sensor ring. This ring would consist of two emitters and two photodiodes across from each other in a “+” shaped design. Light will continuously shine across to each photodiode and every time a liquid interrupts the light, the voltage of this setup will drop.

## 3.3 DESIGN ANALYSIS

We have a mobile application that has properly included facebook into its design. The app can also maintain persistent measurement that can be monitored through the application notification drawer. Facebook is not completely finished because the API requires an address to our app on the play store in order to work. Because of this, we are going to hold off on the features that absolutely require facebook until the app is completely finished.

# 4 Testing/Development

## 4.1 INTERFACE specifications

After numerous meetings with our advisor and client we decided to use bluetooth signal transmitters as our hardware/software interface. Bluetooth communication is the optimum method for our flowmeter device to communicate with the mobile app.

## 4.2 Hardware/software

Hardware:

1. Vishay’s Standard LEDs
   1. We purchased small blue LEDs to serve as a light source in order to test our ambient light sensors.
2. Panasonic’s Standard LEDs
   1. We purchased small blue LEDs(from a different manufacturer) to serve as a light source in order to test our ambient light sensors.
3. Vishay’s Ambient Light Sensors
   1. We had to find and purchase ambient light intensity sensors that were small enough to be feasible with our small flowmeter design. We also needed high quality sensors that had a sufficient level of programmable embedded circuitry in order for us to adjust certain settings and configurations of the sensors. This gives us more flexibility during testing in how we gather, read and transmit the data from the flowmeter device.
4. Vishay’s VEML6030 Add-on Board
   1. We needed this PCB in combination with other vishay software we ordered to run very precise tests on the ambient light sensors we plan on using for our flowmeter. It is important to run a quantitative test to better understand the behavior of the light sensors at varying levels of light intensity.

Software:

1. Vishay’s Sensor Starter Kit
   1. The Sensor Starter Kit contains software specifically designed to test various Vishay light/proximity sensors. This is a crucial component to are testing phase. It displays numerous readings in a “friendly” manner. It also allows us to configure certain settings of the VEML6030 ambient light sensors

## 4.3 Process

* To ensure that the size of our device is small enough to operate properly we purchased a Medela Nipple Sheild and used it’s design to determine our size limit. If a component could fit on the Medela Shield we had to look at different options.
* To test that our device is child proof, we researched official baby proof product criteria. Our research indicated that choke hazards would be our main safety concern for designing our device. Although our actual flow meter device is small, we are going to counter that by encasing it with a rubber mold and attached it to the nipple shield. This increased the overall size of our design.
* To test the accuracy of our ambient light sensors, we purchased the sensor testing software and exposed the light sensors to different levels of light intensity.
* To test the sensitivity of the light sensors we used milk obstruct the light reaching the sensors and used the sensor testing software to observe the changes

# 5 Results

The main results of the testing so far has been majorly from the software side of this project. This is because there was so much caution with the hardware. THe hardware had to meet all safety components while staying small enough to fit into the nipple shield and attain reasonable results. The parts were also not traditional electrical components that we could find easily so a lot of research had to be made . The flow process was also not easy to just pick up and go, so a lot of research had to go into flow studies as well. On the bright side, all the electrical components are efficient and testing will be conducted in these upcoming weeks.

# 6 Conclusions.

On the software side, we have an app that can measure data even when the app isn’t open by making use of the notification drawer. It also features a project bar and the ability to restrict feeding with the same breast twice in a row. The next step for the application is to implement a bluetooth handler and implement some predictive algorithms that can adjust the amount that a mother is supposed to feed based on her previous readings.

On the hardware side we have acquired all of the necessary parts on our project list and are ready to begin assembly and testing. This will allow us to make a formula that can give an amount to the app that is within an acceptable percent error of the raw reading.

Our goal for this semester is to have a working app and working device. From there we can reconfigure the app’s bluetooth handler to integrate with device. We believe this is the best course of action because it allows the hardware and software side to work concurrently and speed up development. In doing this, neither the hardware of software side of the project needs to wait to develop a working concept.

# 7 References

**Flow Techniques**

* Furness, Richard A. (1989). Fluid flow measurement. Harlow: Longman in association with the Institute of Measurement and Control. p. 21. ISBN 0582031656.
* Miller, Richard W. (1996). *Flow Measurement Engineering Handbook* (3rd ed.). Mcgraw Hill. p. 6.16-6.18. ISBN 0070423660.

**Similar Technologies**

* **http://milksense.com/template/english/milksense-tech-en.html**

# 8 Appendices

Figure (1): Purchased Component list

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mouser Part Number | Product Category | Product Size | Manufacturer | Manufacturer Part number | Quantity |
| 997-L1C1-BLU10 | High Power LEDs - Single Color | 2 mm x 2 mm x 1.35 mm | Lumileds | L1C1-BLU1000000000 | 6 |
| 78-VLMB1500-GS08 | Standard LEDs - SMD | 1 mm x 0.5 mm x 0.35 mm | [Vishay Semiconductors](http://www.mouser.com/vishaysemiconductors/) | VLMB1500-GS08 | 6 |
| 667-LNJ947W8CRA | Standard LEDs - SMD | 1 mm x 0.5 mm x 0.2 mm | Panasonic | LNJ947W8CRA | 6 |
|  |  |  |  |  |  |
| 630-APDS-9930 | Ambient Light Sensors | 2.6 mm x 2.2 mm x 0.55 mm | Broadcom / Avago | APDS-9930 | 6 |
| 78-VEML6030 | Ambient Light Sensors | 2 mm x 2 mmx 0.85 mm | [Vishay Semiconductors](http://www.mouser.com/vishaysemiconductors/) | VEML6030 | 6 |
| 78-SENSORSTARTERKIT | Sensor Starter Kit | n/a | Vishay Semiconductors | SENSORSTARTERKIT | 1 |
| 78-VCNL4020X01-GS08 | Proximity Sensors Proximity/IR Emitter AEC-Q101 Qualified | n/a | [Vishay Semiconductors](http://www.mouser.com/vishaysemiconductors/) | VCNL4020X01-GS08 | 3 |

Implementation Details

Arduino UNO:

* Before implementing a physical PCB design, we tested the VEML6030 with an Arduino UNO board. This is because the Arduino UNO has a host microcontroller that we are familiar with in embedding code.
* The ATMEGA328 implements C++ code that can be embedded into its system.
* The VEML6030 has an ADC in which the ATMEGA328 can record the digital values.
* Displaying these values with the Arduino’s serial monitor allowed us to move into the next steps of a PCB design.

PCB:

* For the prototype of this design we decided to go with a flexible printed circuit board.
* The board includes:
  + header connectors for the power supply and for outputting the digital values into the ATMEGA328
  + A 3V regulator that would power the LED and VEML6030 sensors
  + 2.2K and 10K resistors.
  + 10nF and 100nF capacitors in parallel that is used for the setup of the sensors power supply
  + VEML6030 sensors with VLMB1500 LEDs
* The flexible PCB is similar to an “I” shape board where the sensors/LEDs are set up on one end and the rest of the components are on the opposite end.
  + The “I” shape allows for the board to wrap around the breast and the sensor end to be inserted into a nipple shield

Prototype Implementation:

* With a physical prototype the next implementation steps was to set up the board to a funnel in which milk would flow through and record different light intensity values.
* Using an Arduino bluetooth module, the values are sent to the mobile application where the the volumetric rate of flow would be displayed.

Android :

* The software part of our project involves a mobile application. We developed the application using Android Studio therefore it’s only runnable on Android platform supported mobile devices.
* The application is supported by several libraries such as the bluetooth library and BT library on the Arduino side to help sending data.
* The programing languages used are Java for Android to support the backend of the application, XMl to support the user interface and C++ to support the data communication.

Testing Process & Testing Results

Scope of Testing:

The main purpose of our testing procedures was to formulate an equation relating the light intensity(Lux) detected by the sensor to the flow rate(mL/s) of the milk. In order to derive a highly accurate equation, numerous light intensity data points had to be recorded. The flow rate is the controlled variable during this testing process.

Testing Materials:

· Glass beaker

· Glass funnel

· Serological pipette

· Our flowmeter Device

o VEML-6030 test board

o Green LED

· Arduino microcontroller/circuit configuration

· Excel (scatter plot analysis)

· C++ code(Arduino programming interface)

To begin recording the light intensity values correlating to a specific flow rate, we had to construct an adequate testing setup using the materials listed previously above.

We attached the VEML-6030 test board and the green LED directly to the glass funnel. The glass funnel is then partially inserted into the glass beaker. The wires associated with the sensor board and the LED are then connected to the Arduino/Arduino circuit configuration.

We then wrote a code that would be used specifically for our testing process only. This code was designed to read and display the average of 10 light intensity values over a span of 2 seconds (.2 seconds in between each of the 10 values) when milk is being passed through the testing funnel. In order for the data to be meaningful we used a plastic pipette to control the flow rate of the milk.

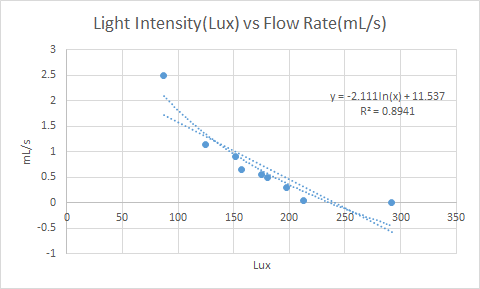
Once we obtained enough data points, we logged the light intensity values(Lux) and their associated flow rates(mL/s) into an excel chart and performed data analysis to obtain linear, exponential, and logarithmic fits.

Testing Results:

Recorded Data:

|  |  |
| --- | --- |
| **Light Intensity (Lux)** | **Flow Rate (mL/s)** |
| 292 | 0 |
| 87.19 | 2.5 |
| 212.31 | 0.05 |
| 197.31 | 0.3 |
| 157.08 | 0.65 |
| 180.37 | 0.5 |
| 175.31 | 0.55 |
| 152 | 0.9 |
| 125 | 1.15 |

Scatter Plot:



Flow Rate = -2.111\*log(Light Intensity)+11.537 R^2= 0.8941

The testing results concluded the logarithmic fit was the most accurate equation to use as it had the highest R^2 value.

Appendix I

Materials/Parts:

· Modified glass funnel w/ attached flow meter device

· Glass beaker

· Arduino / circuit configuration

· Bluetooth Module

· Serological pipette

· Arduino Power Supply Cable

· Bottle of whole milk

· A piece of 8 x 11 printing paper

Hardware Setup Steps:

· Step 1: Gently insert the Modified funnel into the beaker, allowing the wide end of the funnel to rest on the opening of the beaker

· Step 2: Connect the wires associated with the flowmeter and LED to the correct pins on the Arduino breadboard configuration.

-4.7K resistor connected to a parallel connected 10nF & 100 nF capacitors which connects to pin 6 of the VEML6030(VDD)

-Pin 1 of the VEML6030 is grounded

-Pin 3 of the VEML6030 is grounded

-Pin 4 of the VEML6030 is grounded

-Pin 2 connects to the SDA connection of the ATmega328

-Pin 5 connects to the SCL connection of the ATmega328

-2.2K resistor connects to the SDA and the output header

-2.2K resistor connects to the SCL and the output header

· Step 3: Once the flow meter/LED wires are connected to the Arduino configuration plug in the power supply cable and connect it to the Arduino. This will turn on the device and the flowmeter will become active. (begins measuring the flow Rate)

· Step 4: Wrap the 8 x 11 printing paper around the outside of the glass beaker. This will significantly reduce the margin of error by limiting the amount of interference/noise of light from the exterior environment.

*The hardware setup is now complete. Please proceed to the software setup instructions.*

Software Setup Steps:

· Step 1: Turn on your working android device

· Step 2: Download and go into TIt-bit application.

· Step 3: Turn on your bluetooth

· Step 4: Connect to the arduino via Bluetooth

· Step 5: Login to the application

· Step 6: choose the feeding breast

· Step 7: observe the data being displayed.

· Step 8: The data displayed is the real time quantity of milk going through.

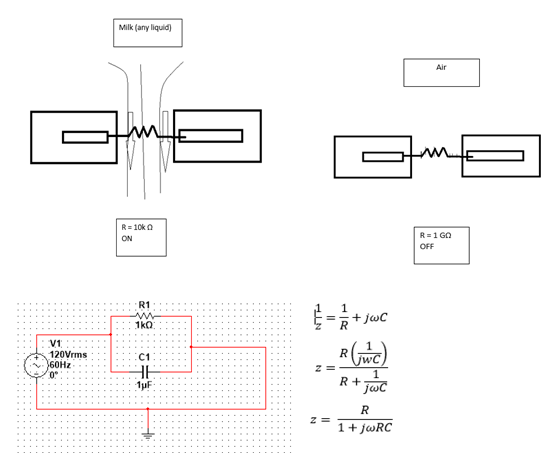
· Step 9: Click done when finish.

Appendix II

This project was very interesting because there was a cluster of ways to try and attack the issue of measuring the flow rate of reading milk and several hardware and software specifications to fiddle with. The product was made to confirm the proof of concept that led and light sensors could read flow rate properly. The final commercialized product will be on the flexible PCB board that this group created if the client chooses to move on with the product. There were several versions of this product that we went through in the planning stages.

**Impedance Method**

The original idea of measuring flow that the group thought of was to measure with an impedance ring.This ring would consist of four plates in which a current will flow through two of these plates and the impedance (resistance and capacitance) would be measured from the other two plates across the current induced plates. When nothing (air) flows through these four plates, the resistance is very high and the capacitance is very low. When a liquid flows through, however, the resistance drops significantly and the capacitance will rise.



The problem with the impedance approach was that the measurement could be affected easily and there were too many factors that could affect our ability to obtain an accurate measurement. We went with the led approach because our advisor suggested it us and further research confirmed. What we did was to measure the change in the led sensors and find an equation that will give an output that is close to the actual amount of liquid that passed through the sensor. In order to find this equation, we plotted the output from the sensor and the actual output into an excel spreadsheet and had Excel make an equation for us. The more data we provided , the more accurate the equation was.

**Final Product( Commercialized)** .

The Titbit was able to to prove itself with the theoretical calculations however the design is not fully finished. The set-up we provided in this course was set solely to provide proof of concept for the client. THe client was satisfied with the results and can move forward with creating a smaller version. The main reason for this was because of the cost and factor of having to work with outside PCB companies that can make flexible boards. It is not common to make a flexible PCBs and the companies that do usually do not make anything for small projects. The average cost for these were ranging from $50,000 or more which is way too much for a university student. One way we could have avoided this would have been to contact multiple PCB companies since the beginning of the project, however the amount of companies that would have been open to making a flexible PCB for a low budget student project would have been small. If the circuit for this project could have been made on a regular PCB, it would have been much easier but the layout was too complex for that. Since the Titbit is going around a woman’s breast, a flat PCB for the sensors would yield no results to collecting flow

Appendix III

Our client wanted user accounts linked to Facebook so that you could login with a Facebook account. An issue we ran into was that the Facebook API requires your application to be published before you can use its functions for logging in and authenticating users. Another issue we ran into was implementing the Bluetooth communication for the device. Our idea was to have the device send the flow rate as a float to the phone and we would use that and the system time to compute how much milk has been fed. However, the Bluetooth communication is used by sending bytes and we had to convert the flow into a series of bytes. We ran into an issue converting from a float to bytes and we never got it working properly. So in order to tackle this issue we took the flow rate and multiplied it by 100 and cast that value to an integer. We knew that this new integer would be between 0 and 256, the range of values for an unsigned char. The device sent our value as a signed char so on the android side we had to convert it to an unsigned char. So to convert it back to our flow rate we checked to see if the value was 0. If it was we added 256 to the number. We then cast the value to a double and divided it by 100 to get it back to our original float value. This works pretty well for us. Another issue had to think about was threading. In android, in order to communicate with a device via Bluetooth another thread is opened up. We also have the device reading Bluetooth values every 5 seconds and we have a timer in another thread initiating Bluetooth communication every 5 seconds. With multiple threads, we had to be cautions that we weren’t opening up too many threads so that we were being too intensive on the CPU.

Originally the hardware design of the flowmeter included 2 sensors and 2 LEDs . The initial thought behind this was to increase accuracy of the readings. If one sensor did not send data to the microcontroller, then the other sensor would be read by the micro controller. Although at first this seemed like a good idea, we later found out that it was unnecessary. This would have over complicated the design. The veml 6030 sensor was efficient enough that it never had an error with communication with the micro controller. This helped us simplify our design and progress quicker

Appendix IV

1. Average Lux Testing Code : Obtains and displays the average light intensity of 10 samples over 2 seconds

*//by Daryck Brown*

*void loop() {*

*float value = als.getALSData()\*0.05;*

*if (value < 300){*

*float sum= 0;*

*Serial.println("Start test!");*

*for(int i = 0; i <10;i++){*

*float data = als.getALSData()\*0.05;*

*Serial.println(data);*

*sum = sum + data;*

*delay(200);*

*}*

*float avg = sum/10.0;*

*Serial.print("avg: ");*

*Serial.println(avg);*

*Serial.println("end of test");*

*delay(10000);*

*}*

*delay(50);*

*}*