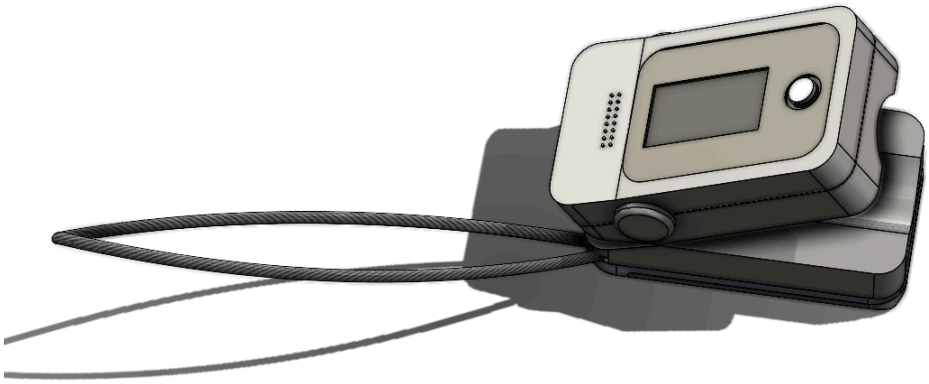

REVERSE ENGINEERING

REPORT

Pulse Oximeter – Shanghai Berry

EDD 103 – Section 54
Project #4

Josh Halpert, Kira Klayman, Belen Kohl, Elysian Lee
10/15/2024

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Device Overview

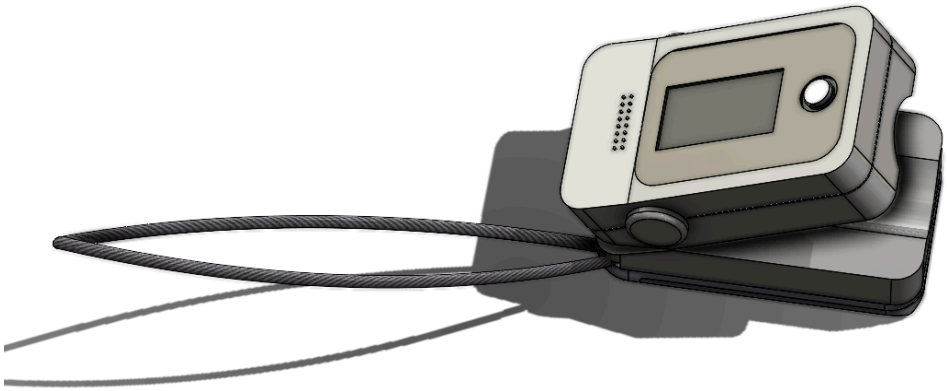


Figure 1: CAD Rendering of Pulse Oximeter

Device Information and Appearance

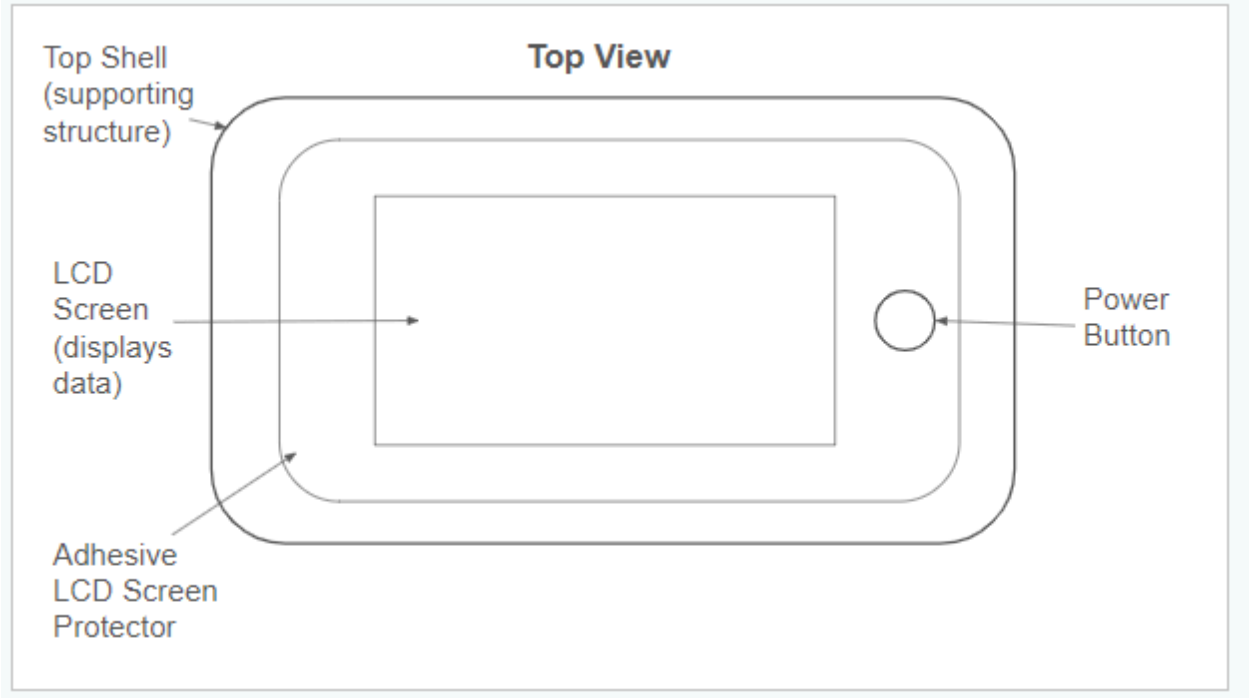
The pulse oximeter was made by Shanghai Berry Electronic Tech Co. in China, and the model number was BM1000C. The device is pocket-sized and very lightweight (2.4 ounces), and its dimensions are 2.36 x 1.89 x 1.38 inches. The device is mostly made up of polypropylene plastic. It has a gray top that borders the screen which displays the user's pulse and oxygen levels. The display can rotate its details to face the user or another person who is checking the user's pulse. The details can also be displayed horizontally or vertically. The device can be opened with a place to comfortably place the user's finger to accurately check their pulse. A lanyard can also be attached to the device to be worn around the user's wrist, allowing for easy transport. It is sold on Amazon for $6.92.

Figure 2: Device Appearance

Device Purpose

This pulse oximeter can be used by anyone who wants to know their pulse at any time. It is portable and has a lanyard to be worn around the wrist so users can easily access the device and check their pulse.

Device Operation



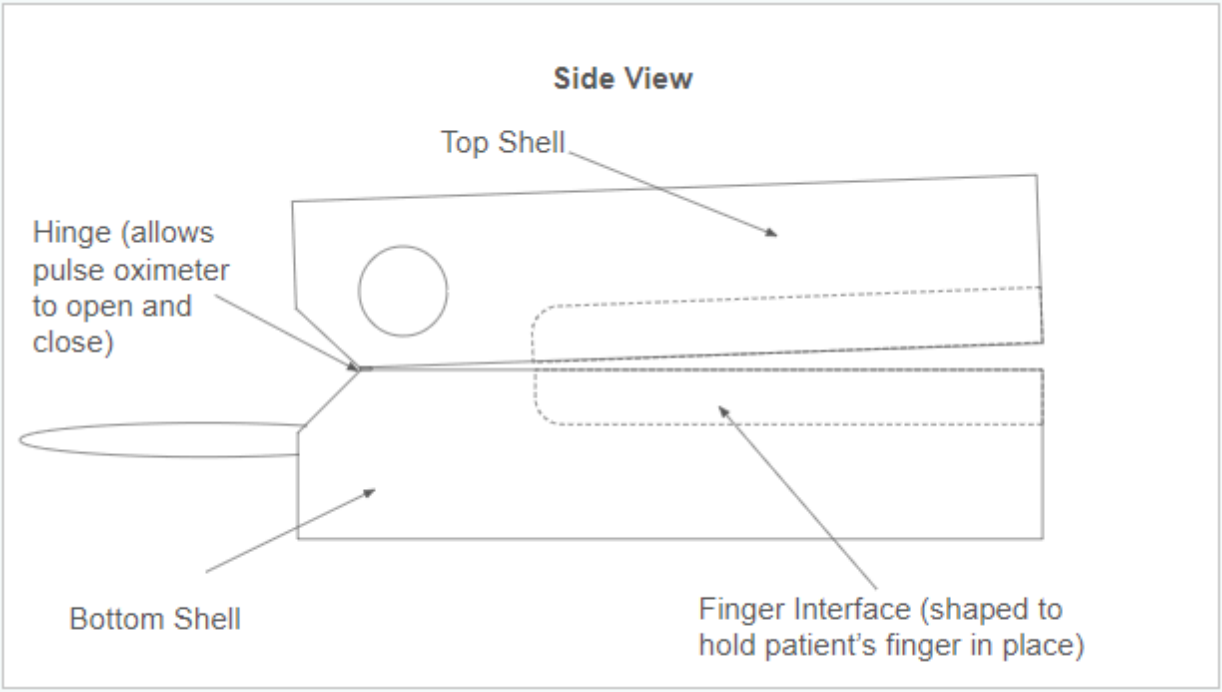


Figure 3: Simple Functional Schematic

To use the device, the user must insert his finger into the finger interface. Then, they must click the button below the screen to activate the device. Once the button is pressed, within 15 seconds, the user can see their blood oxygen levels with the SpO_2 reading and their pulse with the beats per minute reading on the screen. They can also see their pulse strength with the PI% reading. If the user wants to look at the screen at another angle, they must press the button again until they are satisfied with the viewing angle. When the user is done, they take their finger out of the device. The device will turn off by itself after about 10 seconds.

The device works by shining two lights through the user's finger. The first light is red, and the other is an infrared light. Since oxygenated blood absorbs more infrared light and deoxygenated blood absorbs more red light, a sensor on the other side of the finger can sense how much of each light shine through. Using this measurement, the

device can calculate the oxygenation level of the user's blood. The device also finds pulse using the same sensors. The level of light shining through the finger changes as the blood flows to and from the finger. By measuring the change in the amount of light radiating through the user's finger in a certain period, the device can record the user’s pulse (University of Iowa Medicine).

Detailed Description

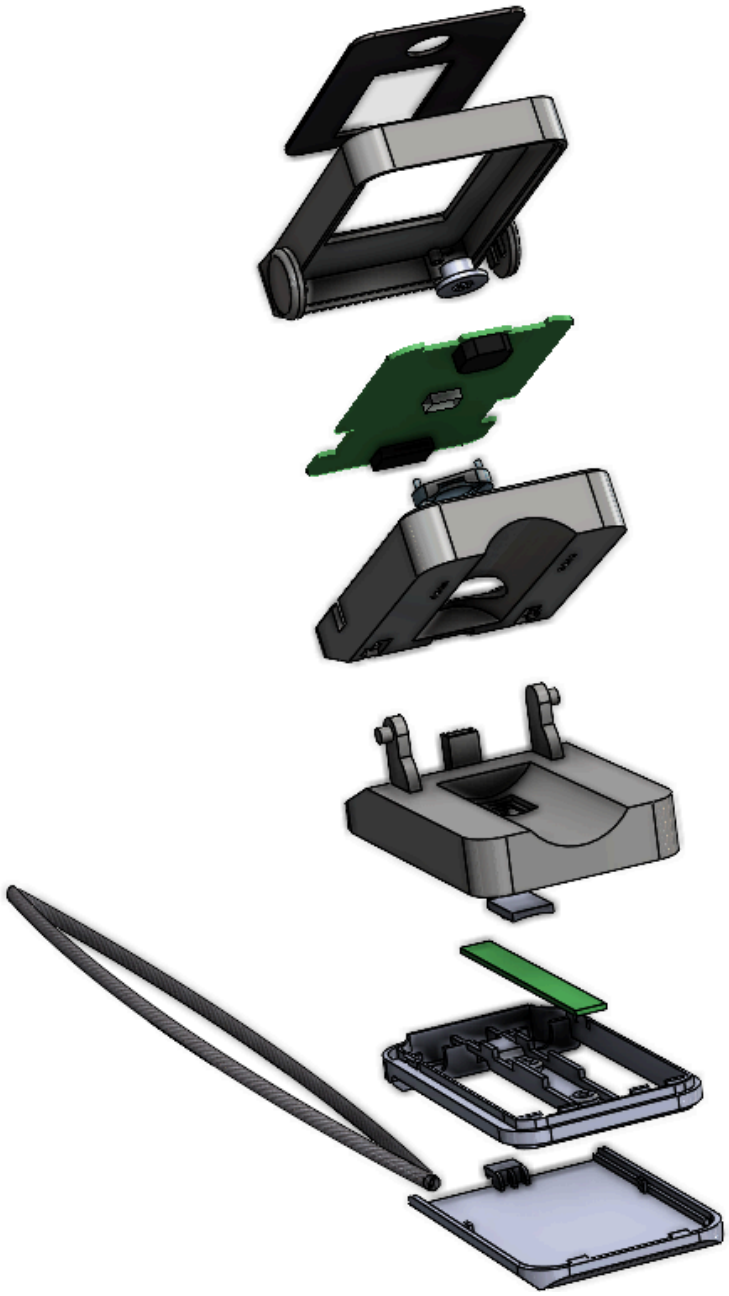


Figure 4: Exploded CAD Assembly

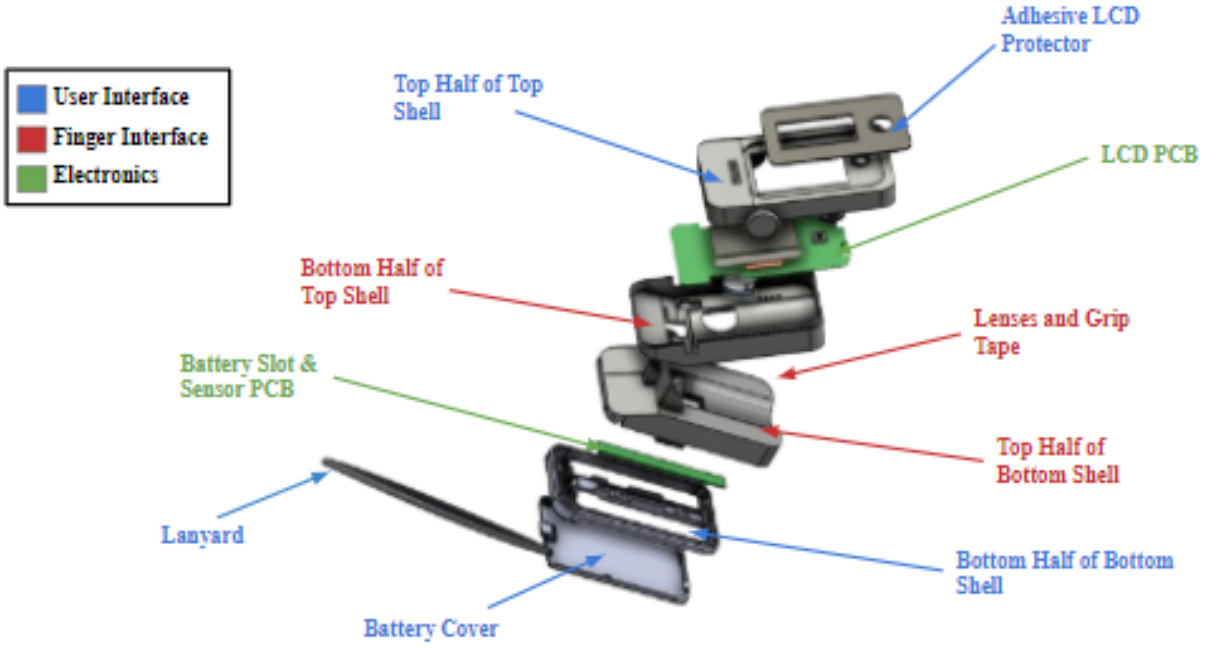


Figure 5: Exploded CAD Assembly Labeled

Assembly Overview

The pulse oximeter consists of four main subassemblies: User interface, finger interface, screws and springs, and Electronics (parts in each subassembly are shown above in Figure 5).

User Interface

Battery Cover (Part 1)

Figure 6: Picture of battery cover

The battery cover is made of polypropylene plastic. It is an easily removable bottom plate which allows the AAA batteries to be easily swapped when they die.

Top Half of Top Shell (Part 17)

Figure 7: Picture of top half of top shell

The half of the top shell is made of polypropylene plastic. It is the topmost part of the housing and holds the button cover and a cutout for the LCD and Adhesive LCD protector. This part of the shell also helps contain and protect the components inside.

Adhesive LCD Protector (Part 18)

Figure 8: Picture of Adhesive LCD Protector

The LCD protector, made of polypropylene, is a thin, transparent piece of plastic that protects the LCD panel from dust and scratches.

Bottom Half of Bottom Shell (Part 4)

Figure 9: Picture of Bottom Half of Bottom Shell

The bottom half of the bottom shell, made of polypropylene, is the bottommost part of the housing and serves as a piece for the battery cover to attach to protect inside components.

Lanyard (Part 5)

Figure 10: Picture of Lanyard

The lanyard has a polypropylene base with a thin strong that attaches to a cutout in the bottom housing. On the other side of the base, there's a polyester strap for the device to be worn around the user's wrist. Once the string of the lanyard is slipped through the hole in the bottom housing, it is attached, which allows for easy transport.

Button Cover (Part 15)

Figure 11: Picture of the Button Cover

The button cover, made of polypropylene, aligns above the button attached to the LCD PCB. This part provides further tactile feedback when interacting with the device.

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Finger Interface

Top Half of Bottom Shell (Part 7)

Figure 12: Picture of the Top Half of the Bottom Shell

The top half of the bottom shell, also made of polypropylene plastic, provides a mounting point to the Grip Material and top sensor Lens. This part of the shell also helps contain and protect the components inside.

Bottom Half of Top Shell (Part 11)

Made of polypropylene plastic, the bottom half of the top shell protects the components inside and provides a mounting point for the grip material and bottom sensor lens.

Figure 13: Picture of the Bottom Half of the Top Shell

Grip Material (Part 8)

Figure 14: Picture of the Grip Material

The black adhesive strips are made of rubber and contain tape on the backside to stick to the housing. This grip material provides more comfort to the user's finger when operating the device by adding cushioning over the hard plastic exterior. The grip material also contains cutouts for the top and bottom sensors.

Bottom Sensor Lens (Part 9)

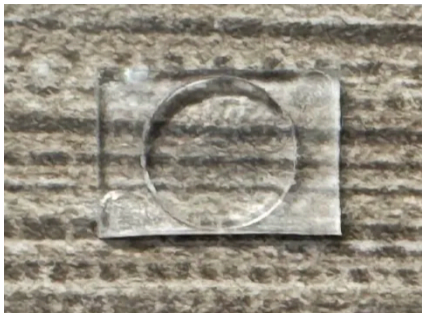

Figure 15: Picture of the Bottom Sensor Lens

The bottom sensor lens is made of clear ABS (Acrylonitrile Butadiene Styrene) plastic which is a strong polymer plastic with high transparency (Vexma). This lens helps scan the pulse of the inserted finger through a clear plastic part.

Top Sensor Lens (Part 10)

Figure 16: Picture of the top sensor lens

The top sensor lens, also made of Clear ABS, helps scan the pulse of the inserted finger through a clear plastic part.

Top Shell Bottom Half

Figure 17: Picture of the Bottom Half of the Top Shell

Provides a mounting point to the Grip Material and Top Sensor Lens. This part of the shell also helps contain and protect the components inside.

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Electronics

1.5 AAA Batteries (Part 2)

Figure 18: Picture of the Batteries

These 1.5 AAA batteries are made of alkaline, lithium-ion, and nickel. They provide power to the Pulse Oximeter.

Battery Slot and Sensor PCB (Part 6)

Figure 19: Picture of the Battery Slot and Sensor PCB

The battery slot and sensor PCB is made of a few materials, including epoxy resins, copper, and fiberglass. They are a connection point for the AAA batteries; the sensor on the PCB reads the finger pulse data.

Ribbon Cable (Part 14)

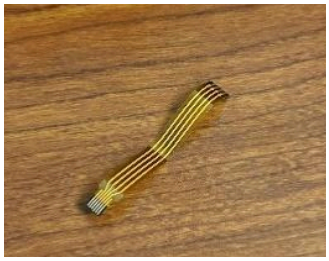

Figure 20: Picture of the Ribbon Cable

The ribbon cable is made of a thin, flexible copper material to take up minimal space inside the device. It serves an important function though, as it transfers data from the Sensor PCB to the LCD PCB.

LCD PCB (Part 16)

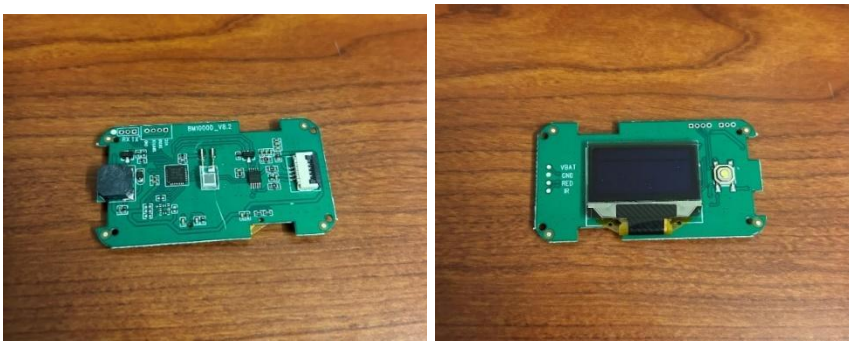

Figure 21: Pictures of the LCD PCB

The LCD PCB is made of epoxy resins, copper, and fiberglass. This part holds the LCD screen and button in place. It also receives sensor and button data and displays the information on the LCD screen.

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Screws and Springs

Bottom Shell Screws (Part 3)

Figure 22: Picture of Bottom Shell Screws

These are 18-8 Stainless Steel Phillips Screws, M1.6, and are 4mm in length. This set of screws connects the bottom shell and the bottom half to hold the device together.

Clamp Springs (Part 12)

These springs, made of stainless-steel wire, secure the finger in place over the sensor. They connect the bottom and top shell and allow the device to remain closed over the finger while taking the user's pulse.

Figure 23: Picture of Clamp Springs

PCB Screws (Part 13)

These are 18-8 Stainless Steel Phillips Screws, M1, and are 3mm in length. This set of screws connects the circuit board to the device.

Figure 24: Picture of PCB Screws

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Review

Review Methods

For many reviews, the reviews on Amazon were looked at. Reviews were chosen that were descriptive and relevant. For example, if a review stated that the

pulse oximeter was a “bad product,” it was not included. However, if a reviewer described a bad experience with the product, that style of review was included in our report. Other websites with similar or better products were looked at to see what features can be improved or added to this device. The pulse oximeter was also tested by each group member to see the different features. For example, the various ways the pulse oximeter can rotate the details on the screen, how the device finds the user's pulse, and how long the device takes, on average, to display the details.

Table 1: Pros and Cons

Pros	Cons
• Calculates heart and oxygen levels within seconds • Various settings that adjust the details of the display to face the user or another person checking the user’s pulse (Jacklyn C) • Details can be rotated both vertically and horizontally (Jacklyn C) • Has a lanyard which can be worn around the wrist for portability	• Difficult to place lanyard through hole (BkWurm1) • Short lifespan (Cynthia) • Not all the features work all the time (K. McReynolds)

Pros

It’s a quick, simple way to measure heart rate and oxygen levels. Additionally, after the power button powers on the device, if it’s clicked again, there are various settings,

including sound, vertical or horizontal display, or the details can be rotated, which is very useful if someone else needs to see the user's pulse (Jacklyn, C).

Figure 25: Pictures of vertical and horizontal display settings

Cons

During use, it was difficult to put the lanyard through the designated hole, making it hard to allow for easy wear around the wrist (BkWurm1).

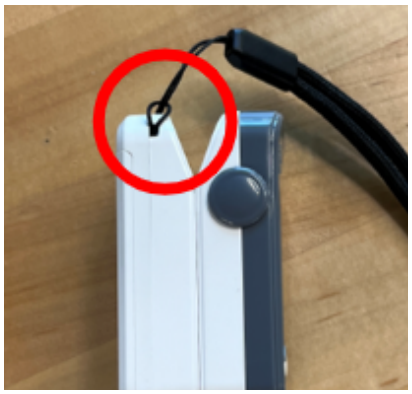


Figure 26: Picture of small lanyard hole (circled)

Although the pulse oximeter wasn't used for long before being taken apart, an Amazon review said its lifespan wasn't very long, and it stopped working after a short time (Cynthia).

Additionally, not all of the features worked all the time. For example, automatically turning off or beeping with the user's heart rate only worked about half the time (K. McReynolds).

Modifications

There are other pulse oximeters that connect to smartphones and have more features, including memory and tracking history. This feature can be very helpful for remembering or tracking how the user's pulse differed over a period of time or for sharing the information with the user's doctor. Some pulse oximeters contain special sensors for even more accuracy or smart springs that can adjust to the user's finger size (Oxiline). There are also pulse oximeters with lanyards that are much simpler to attach or thread through the designated slot (Sonohealth).

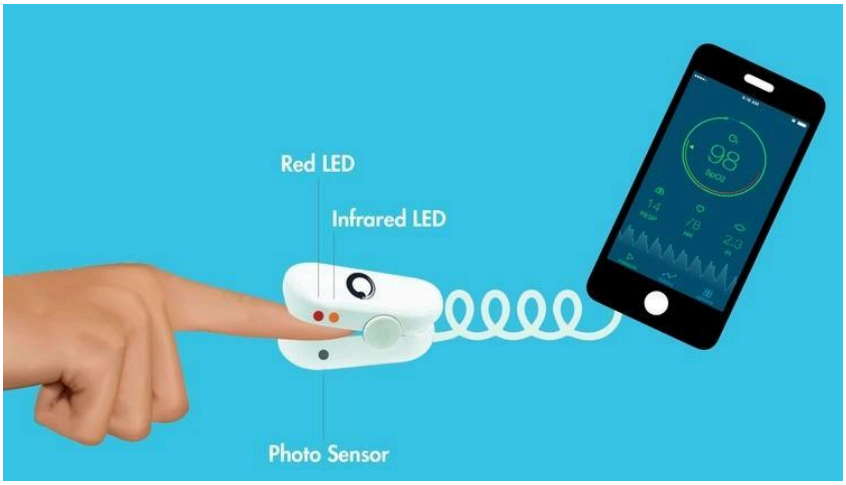


Figure 27: Pulse Oximeter with Smartphone Connection

Summary

The pulse oximeter measures a user's pulse within a matter of seconds. To study the device, the pulse oximeter was tried a couple times on different group

members as well as its different features. This device is super convenient, easy to use, and checks heart rate and oxygen levels in about eight to ten seconds. It is a good price compared to other pulse oximeters with similar features. Although the device has many features, a simpler way to attach the lanyard or some type of memory to keep track of previous uses would improve the device.

References

University of Iowa Medicine, “Pulse Oximetry Basic Principles and Interpretation”, https://medicine.uiowa.edu/iowaprotocols/pulse-oximetry-basic-principles-and-interpretation

Vexma Technologies, “Transparent ABS,” https://vexmatech.com/transparent-abs#:~:text=Transparent%20ABS%20(Acrylonitrile%20Butadiene%20Styrene,%2C%20impact%20resistance%2C%20and%20transparency.

Jacklyn C (2024, May). Amazon.com: FINGERTIP OXIMETER https://www.amazon.com/gp/customerreviews/R2HL3JT3JWFRUF/ref=cm_cr_arp_d_rvw_ttl?ie=UTF8&ASIN=B0BSCLBV3V

BkWurm1 (2024, May). Amazon: FINGERTIP OXIMETER https://www.amazon.com/gp/customerreviews/R2C54ERSB0VQRU/ref=cm_cr_getr_d_rvw_ttl?ie=UTF8&ASIN=B0BSCLBV3V

Cynthia (2024, May) Amazon: FINGERTIP OXIMETER

https://www.amazon.com/gp/customerreviews/R1KRB5B7R8Y77O/ref=cm_cr_dp_d_rvw_ttl?ie=UTF8&ASIN=B0BSCLBV3V

McReynolds, Kamaria (2024, May). Amazon: FINGERTIP OXIMETER

https://www.amazon.com/gp/customer-reviews/RZP2JU1X9ZOAY/ref=cm_cr_arp_d_rvw_ttl?ie=UTF8&ASIN=B0BSCLBV3V

Oxline, Pulse Oximeter: Pulse XS Pro

https://oxiline.shop/product/pulsexspro/?utm_source=Google+Shopping&utm_medium=cpc&utm_campaign=googlesheets&gclid=CjwKCAjw8rW2BhAgEiwAoRO5rEWaH_DTBIo9IFN9ttJRdROWR2SpRQyAHyRonueywSZ_XKTcpjK1lhoCDP0QAvD_BwE&campaignid=19641048172&adgroupid=&loc_physicall_ms=9005440&loc_interest_ms=&matchtype=&network=x&creative=&keyword=&placement=&targetid=&gad_source=1

Sonohealth, Pulse Oximeter - Check Oxygen Concentration in Blood

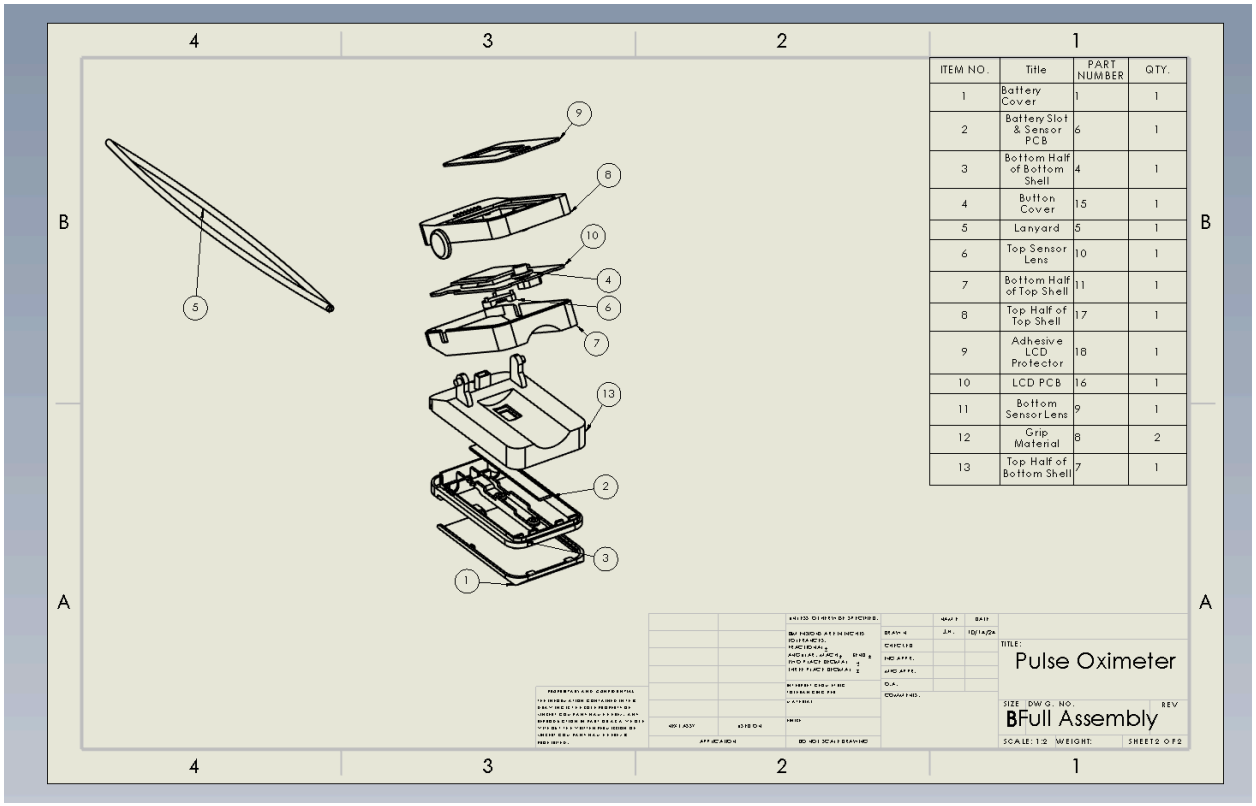
https://sonohealth.com/product/pulse-oximeter-check-oxygen-concentration-in-blood/?gad_source=1&gclid=CjwKCAjw8rW2BhAgEiwAoRO5rAPAsdGiGHC9p92ruvsQUnM47e1ik2p8NZJO3HwyxY0jvb64Y8WxLxoCSvkQAvD_BwE

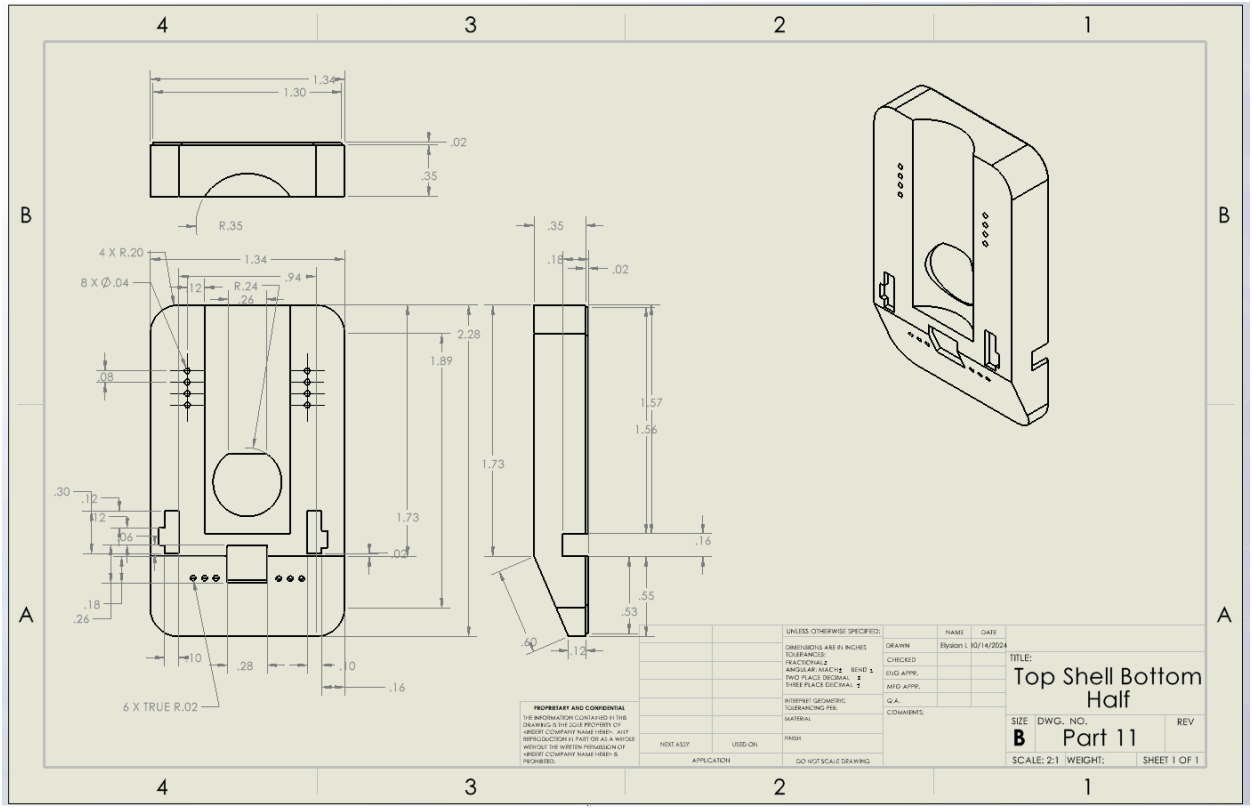
Concord Health Supply, “iOximeter Smartphone Pulse Oximeter for Android, iPhone, and iPad,”

https://www.concordhealthsupply.com/iOximeter-Smartphone-Pulse-Oximeter-p/75005.htm

Appendices

Appendix A: CAD Drawings

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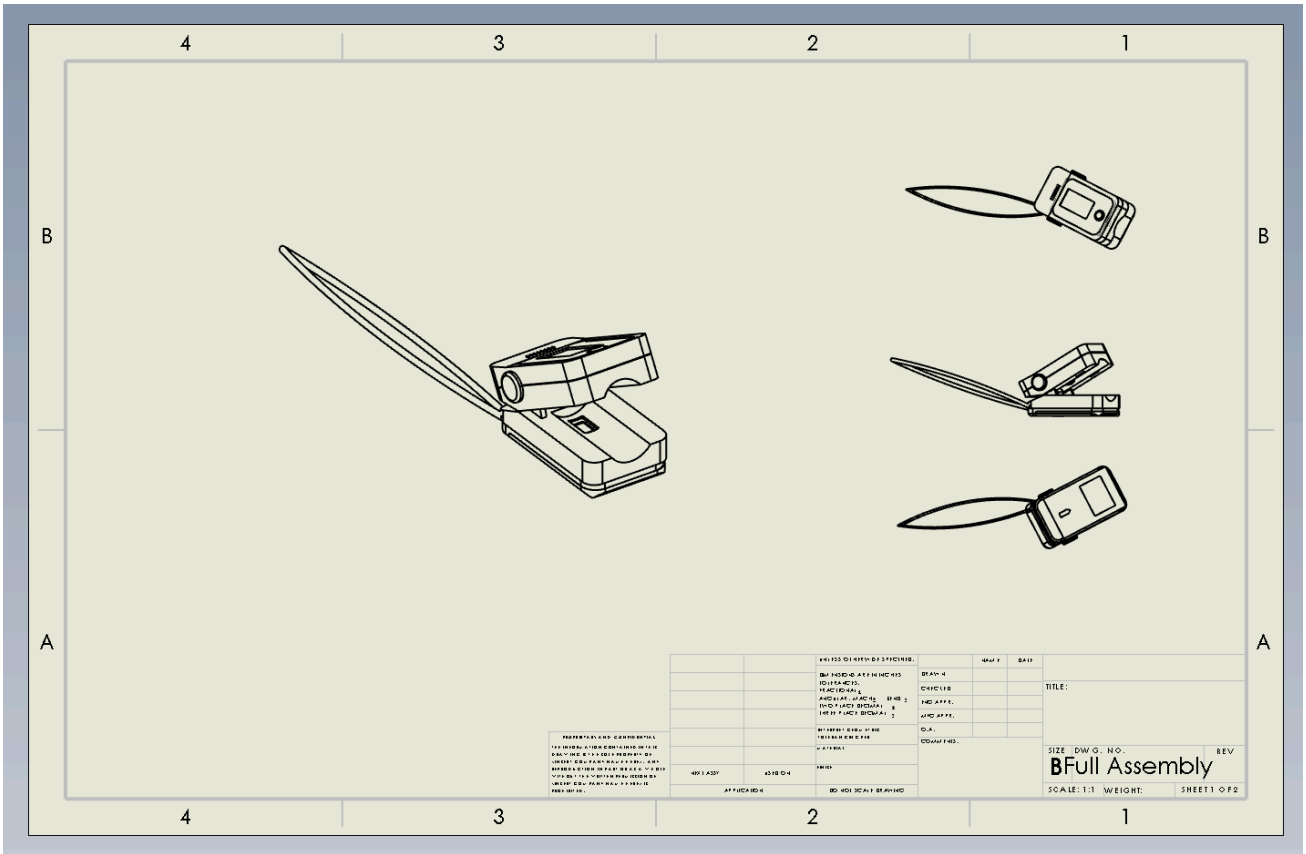
8 X Ø.04
R.35
R.24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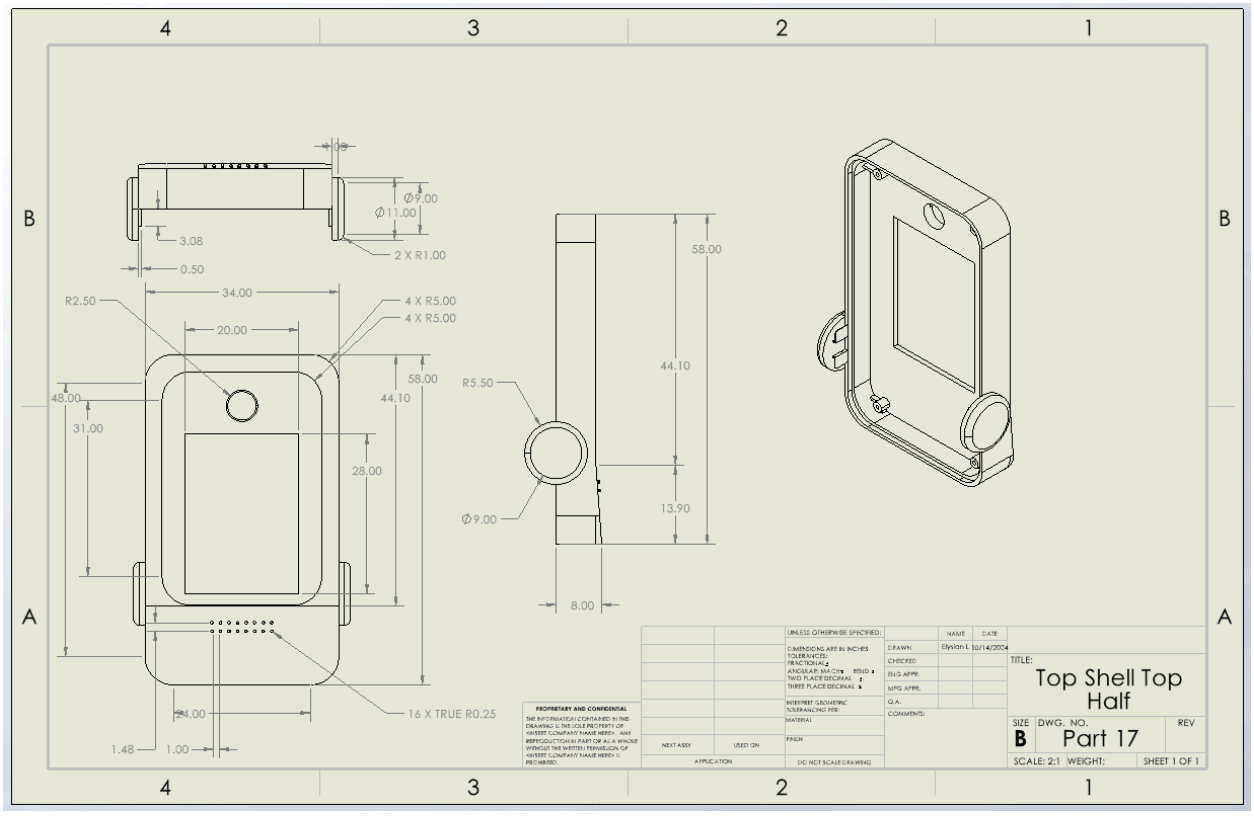
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48.00
44.10
31.00
28.00
R5.50
Ø9.00
58.00
44.10
13.90
8.00
16 X TRUE R0.25
24.00
1.48
1.00
PROPRIETARY AND CONFIDENTIAL
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
Elyion L 10/14/2024
TITLE:
Top Shell Top Half
SIZE
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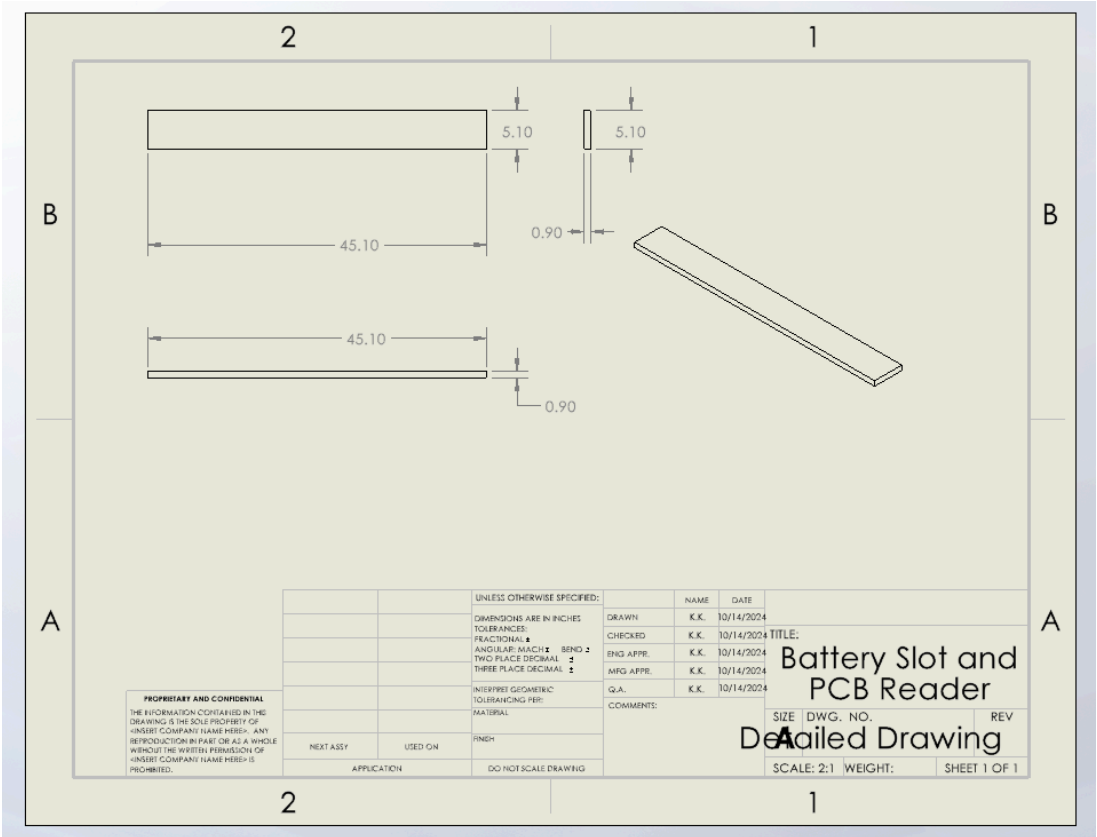
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45.10
45.10
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ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
K.K. 10/14/2024
TITLE:
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Detailed Drawing
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REV
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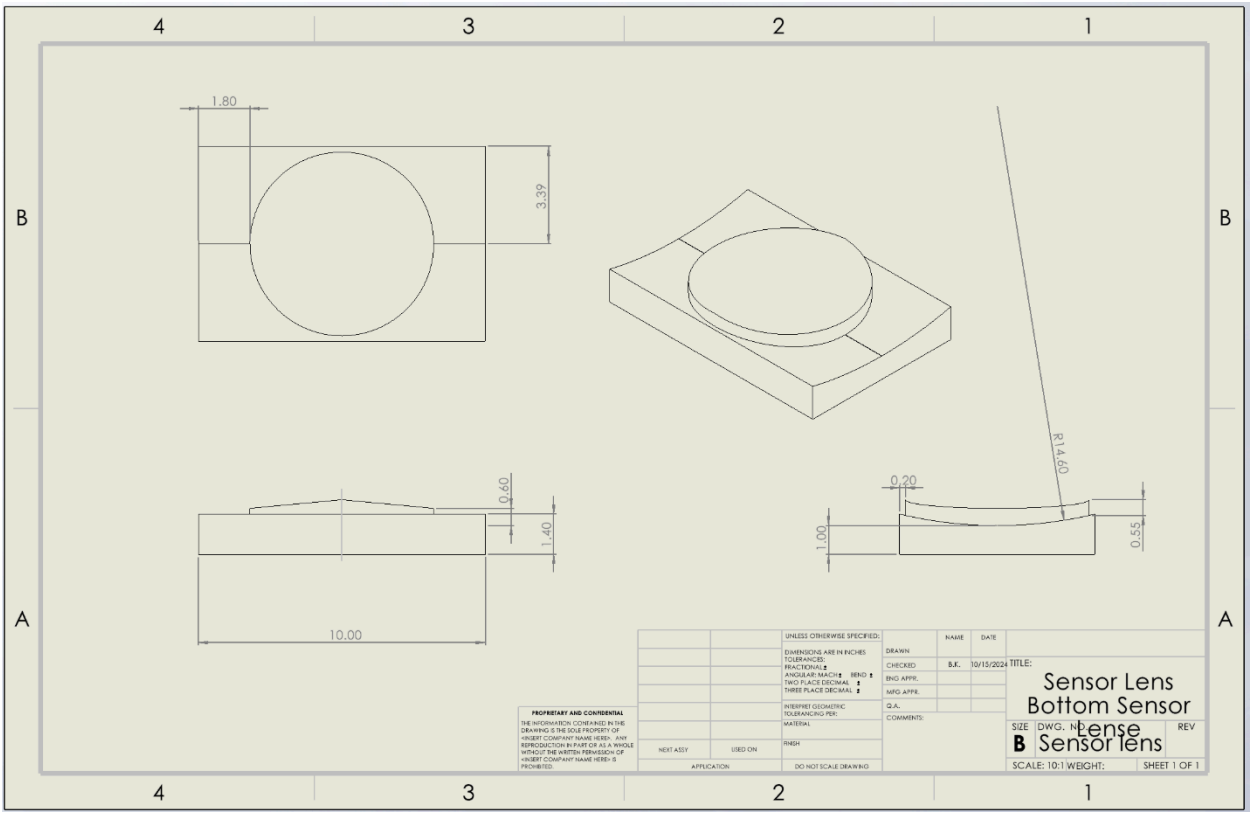
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING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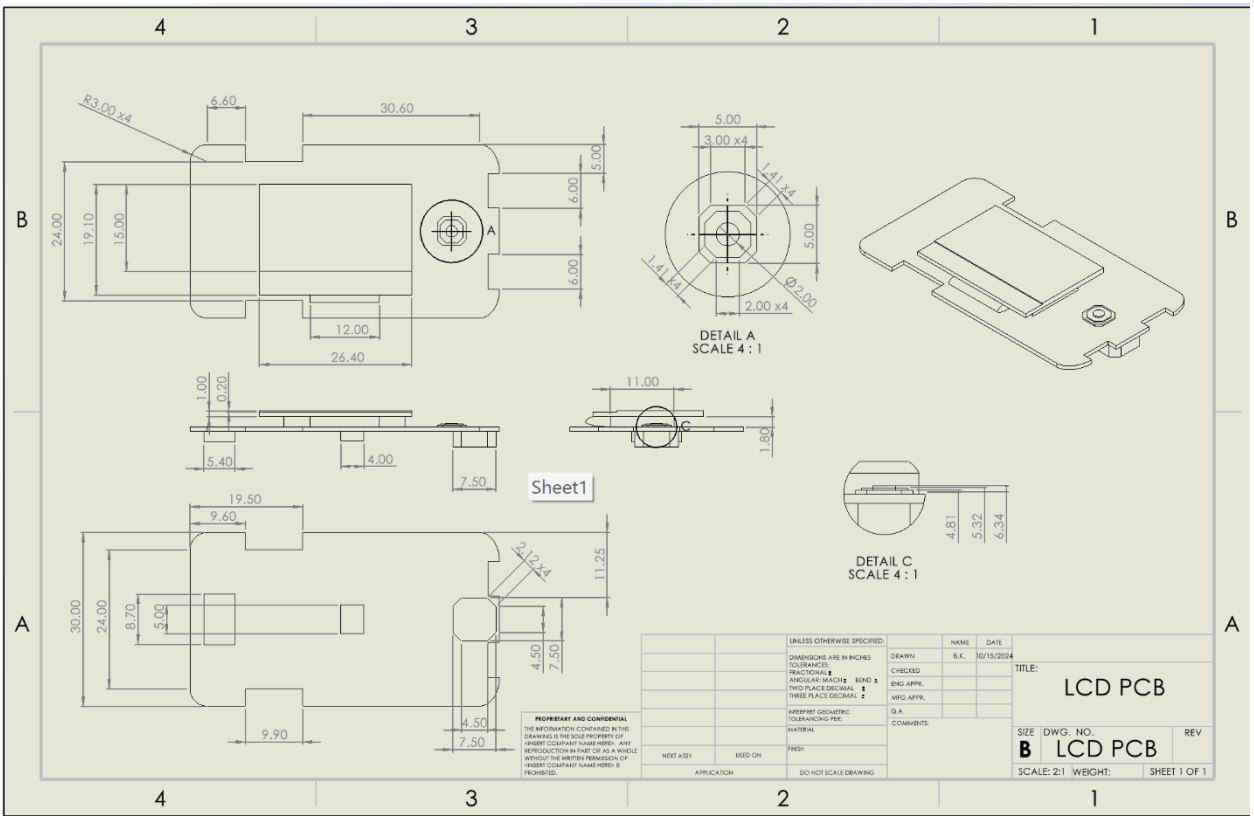
Bottom Sensor
Lense
Sensor lens
B.K.
10/15/2024
SCALE: 10:1
SHEET 1 OF 1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30.60
5.00
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6.00
24.00
19.10
15.00
12.00
26.40
5.00
3.00 x4
1.41 x4
5.00
1.41 x4
Ø2.00
2.00 x4
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0.20
5.40
4.00
7.50
11.00
1.80
Sheet1
19.50
9.60
2.12 x4
11.25
30.00
24.00
8.70
5.00
4.50
7.50
9.90
4.50
7.50
4.81
5.32
6.34
DETAIL C
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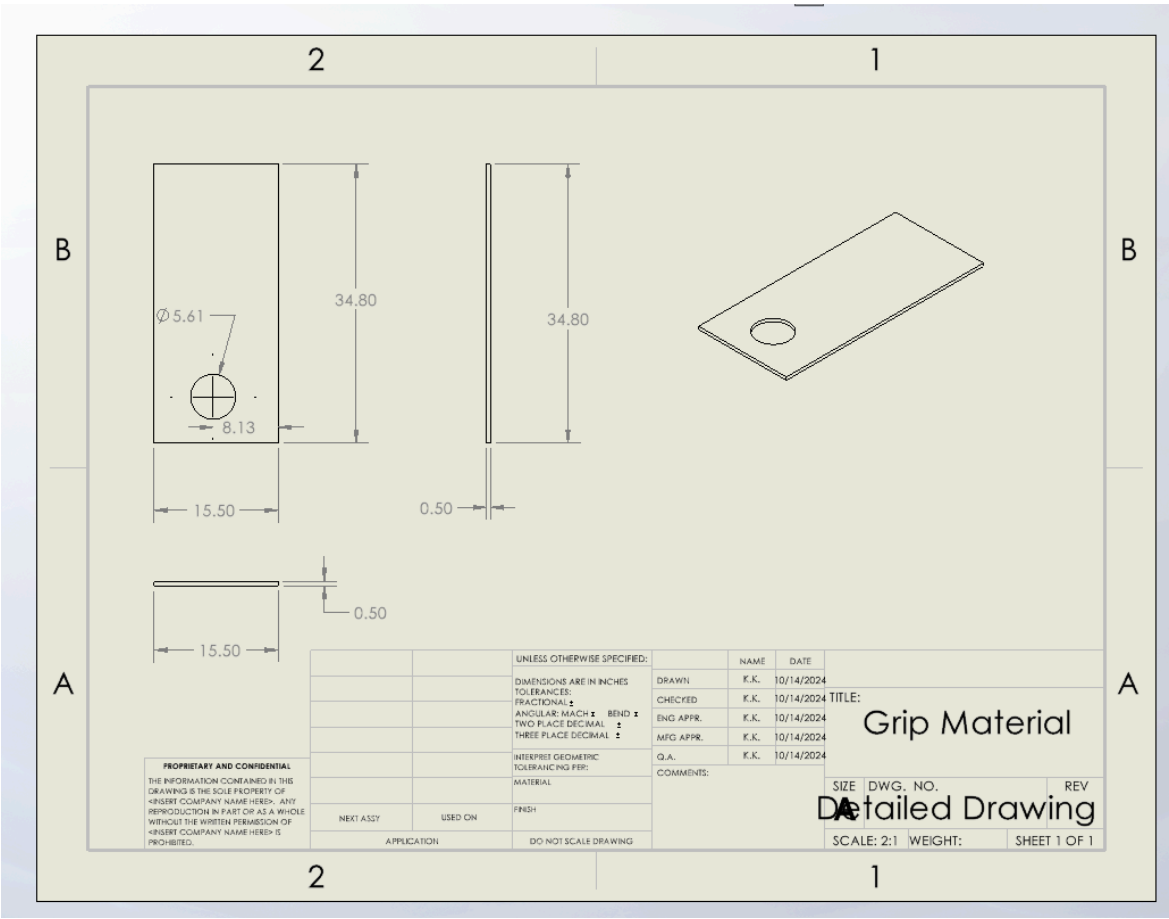
B.K.
10/15/2024
LCD PCB
LCD PCB
SCALE: 2:1
SHEET 1 OF 1



Appendix B: Functional Bill of Materials

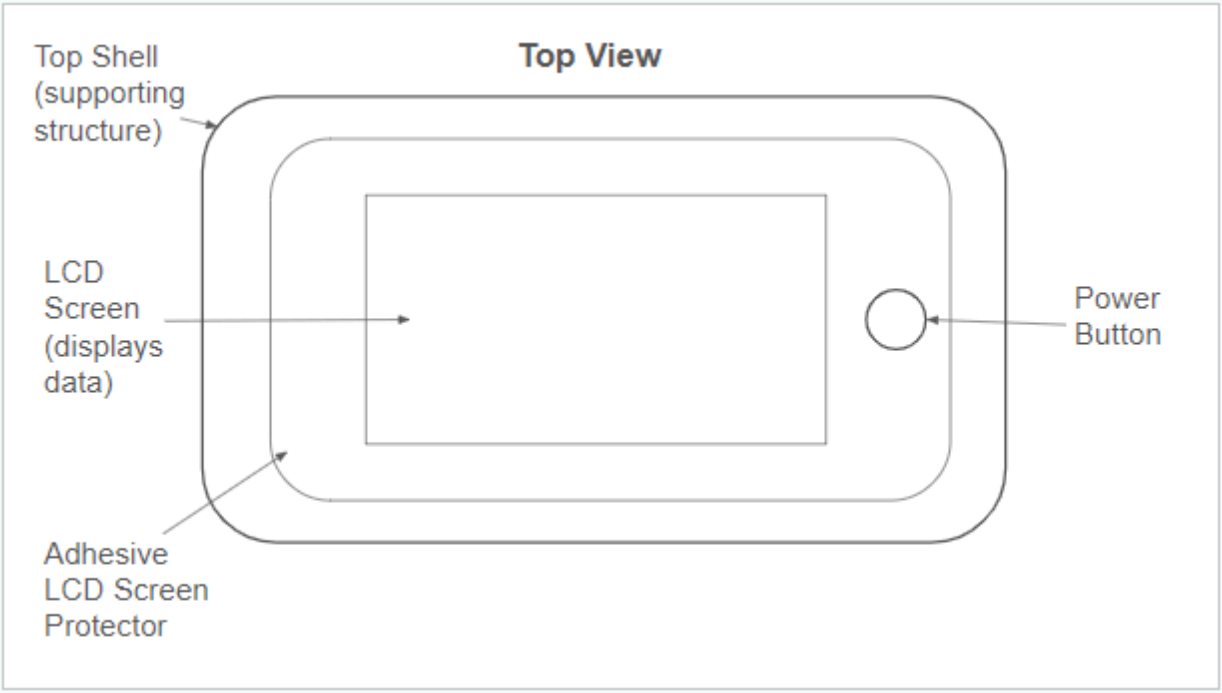
Part Number	Part Name	Quantity	Classification (Custom or Standard)	Material	Function(s) of Part
1	Battery Cover	1	Custom	Polypropylene	Protects the batteries
2	1.5 V AAA Batteries	2	Standard	Alkaline, lithium-ion, and nickel	Powers the device

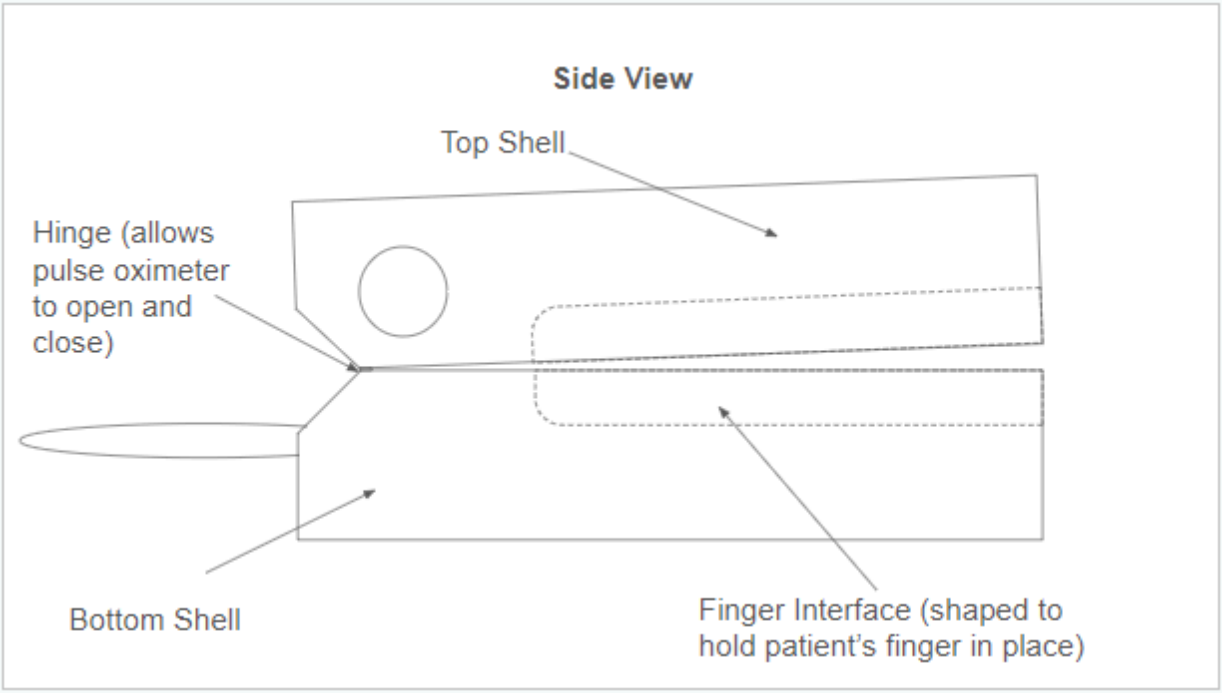
3	Bottom Shell Screws	2	Standard	18-8 Stainless Steel	Screws into the bottom shell bottom half to hold the device together
4	Bottom half of bottom shell	1	Custom	Polypropylene	Aesthetics of the supporting structure
5	Lanyard	1	Standard	Polyester, Polypropylene	Allows pulse oximeter to be held around wrist
6	Battery Slot & Pulse Reader PCB	1	Custom	FR4, Copper	Draws power from batteries, controls power flow and data output to and from the sensor, holds the sensor in place
7	Top Half of Bottom Shell	1	Custom	Polypropylene	Secures finger in place over sensor

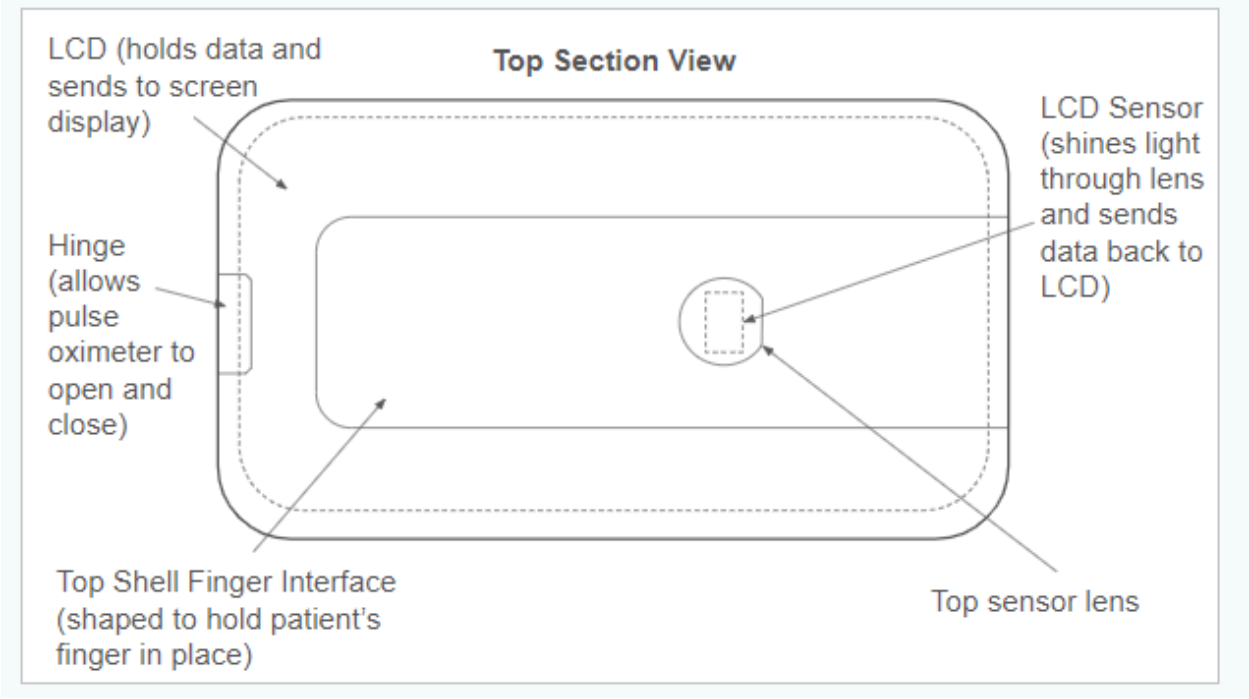
8	Grip Material	2	Custom	Rubber, Adhesive	Comfort the supporting of the finger
9	Bottom Sensor Lens	1	Custom	Clear ABS	Protects the sensor from damage and dust
10	Top Sensor Lens	1	Custom	Clear ABS	Protects the sensor from damage and dust
11	Bottom Half of Top Shell	1	Custom	Polypropylene	Secures finger in place over sensor
12	Clamp Springs	2	Custom	Stainless Steel Wire	Secures finger in place over sensor
13	PCB Screws	4	Standard	18-8 Stainless Steel	Holds the circuit board in place
14	Ribbon Cable	1	Custom	Copper	Provides power and data to the screen
15	Button Cover	1	Custom	Polypropylene	Protects and provides better

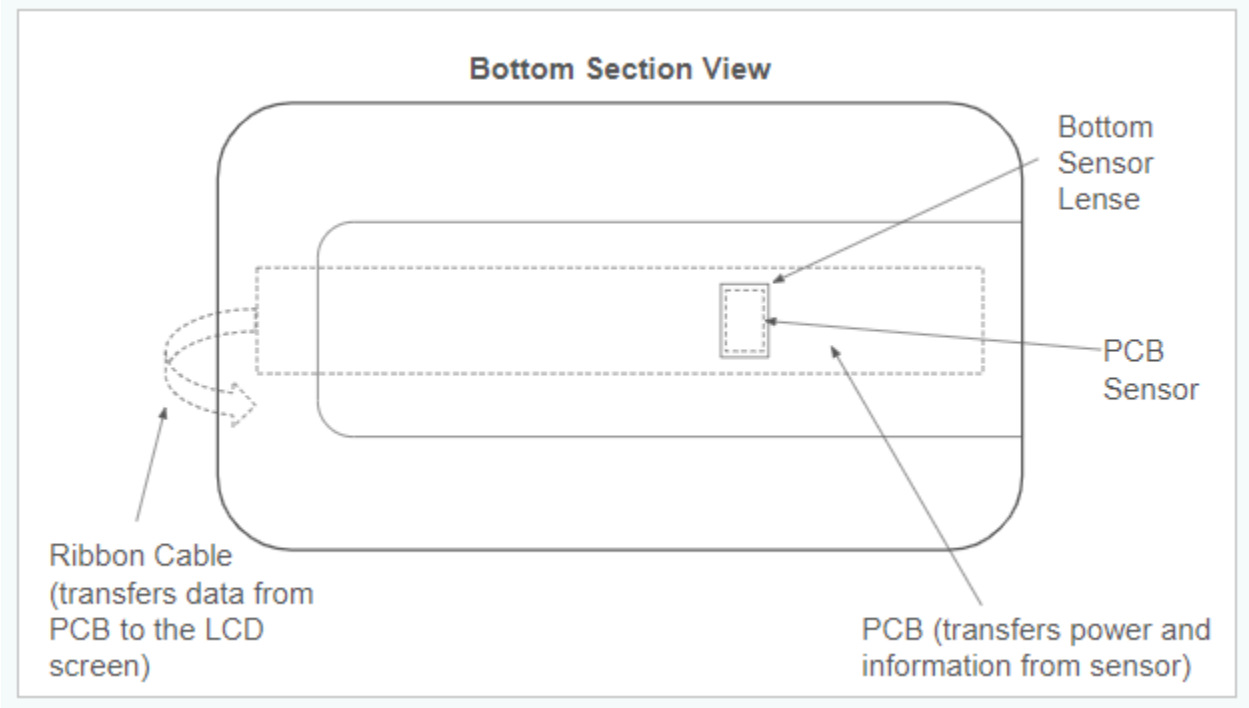
					ergonomics for button pressing
16	PCB & LCD	1	Custom	FR4, Copper	Supports, controls energy flow, and provides data to the screen and button
17	Top Half of Top Shell	1	Custom	Polypropylene	Aesthetics of the supporting structure
18	Adhesive LCD Protector	1	Custom	Polypropylene	Protects the screen from damage and dust

Appendix C: Detailed Functional Schematic






Top Section View
LCD (holds data and sends to screen display)
LCD Sensor (shines light through lens and sends data back to LCD)
Hinge (allows pulse oximeter to open and close)
Top Shell Finger Interface (shaped to hold patient's finger in place)
Top sensor lens


Bottom Section View
Bottom Sensor Lense
PCB Sensor
Ribbon Cable (transfers data from PCB to the LCD screen)
PCB (transfers power and information from sensor)

Appendix D: Functional Flowchart