User Manual

Biomedical Sensor Board for Education - MediBrick 2000

ENGR 498B - #24052

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REVISION PAGE

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1	04/23/2024	Set up the document, wrote the introduction, safety, OLED, and temperature-specific sections	Michael Morrett
2	04/24/2024	Wrote Final Sensor Housing Assembly, System Startup, System Shutdown	Michael Morrett
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1.0 INTRODUCTION

The MediBrick 2000 was designed for Urs Utzinger, PhD, of the University of Arizona's Department of Biomedical Engineering. It was designed through the Craig M. Berge Engineering Design Program by Project Team 24052; this team included Carmella Ocaya (Biomedical Engineering) as the Project Leader, Muad Alsayar (Electrical and Computer Engineering) as the Procurement Leader, Michael Morrett (Biosystems Engineering) as the Documentation Leader, Alec Newman (Mechanical Engineering) as the Assembly Leader, and Daniel Campana (Electrical and Computer Engineering) as the Research and Development Leader. The Project Mentor overseeing the progress of this project was Mr. Stephen Larimore.

This system is an open-source modular biomedical sensor array designed to be used in an educational setting. It is capable of measuring body temperature, skin impedance, heart ECG, pulse oximetry, heart rate, and heart sounds through detachable sensor modules. As it is a modular system, is it possible for other sensors to be utilized within this system, so long as they conform to the specifications of the sensor housings. It is also possible for microcontrollers other than the ESP32-S3 microcontroller to be used, but that would require slight redesigns or modifications to the housings and codes. For both educational institutions and private individuals wishing to use this system, it is recommended that this system is used in its base configuration first before seeking to make modifications. This would allow the User to learn how the system works and what modifications they wish to make to it before investing in making those changes.

This manual details the instructions required to assemble, calibrate, and use this system to take physiological measurements. General instructions and subsystem-specific instructions are listed in each section. For detailed information on the design of this system, please refer to the Technical Data Package, the Final Report, and the Design Documentation provided on the GitHub page of this system, linked as https://github.com/grender007/Modular-Biomedical-Sensor-Board-for-Education. The Sponsor also possesses a GitHub repository where he posts information and designs for his version of this project and additional sensors, linked as https://github.com/uutzinger/BioMedicalSensorBoard.

We the design team appreciate you using the MediBrick 2000, and we hope this system meets your needs.

2.0 SAFETY INSTRUCTIONS

This section details the safety information for the MediBrick 2000. Some sensors of this device utilize electrodes carrying current connected directly to the skin of an individual. Electrical surges through the electrodes carry the possibility to **GRIEVOUSLY INJURE OR KILL** an individual connected to the device. For the safety of all utilizing this device, **DO NOT VIOLATE ANY OF THE SAFETY INSTRUCTIONS** located within this section of the manual. **DO NOT USE THIS DEVICE WITHOUT READING THESE SAFETY INSTRUCTIONS.**

2.1 ELECTRICAL SAFETY

Do not operate a sensor while the sensor module in use is charging or is connected to the Charging Module. Operating a sensor module while the module is connected to an external power source has the potential to result in bodily injury for the individual connected to the

sensor. For the safety of the individual connected to the sensor probe, do not use the sensor module while it is charging or connected to an external power source. If a sensor module needs to be charged, completely disconnect it from an individual before returning the sensor to the Charging Module or connecting it to any other external power supply.

Do not leave the system unattended while it is operating. The system contains lithium-ion batteries which carry the unlikely possibility of catastrophically failing and starting a fire. As such, always ensure that someone is there while the system is operating, and that the system is properly shut down with all batteries disconnected when no longer operating.

2.2 BIOLOGICAL SAFETY

In order to prevent contracting illnesses from the sensor modules, it is recommended that the temperature sensor probe, the pulse oximeter probe, and the stethoscope probe be sanitized after each use. To sanitize these sensors, disconnect the sensor from its port, take an alcohol wipe, and gently wipe the piece of the probe that contacts skin with the alcohol wipe. Allow up to five minutes for the alcohol to evaporate before reconnecting and using the sensor again. Do not sanitize with bleach-based cleaners.

To use the temperature probe without needing to sanitize the sensor after each use, put a catheter thermometer probe cover onto the temperature sensor probe. Remove the cover after each use. Do not reuse the disposable probe covers.

Do not reuse the disposable electrodes for the skin impedance and ECG sensor modules.

2.3 CHEMICAL SAFETY

Do not leave the electrodes attached to skin for extended periods of time. In order to avoid skin irritation, it is recommended that skin is not in contact with the electrode pads for more than three hours. After such time, it is recommended that the electrode pads be removed and disposed of. If use of the sensor is required after this three hour period, new electrode pads can be applied to a different patch of skin.

Do not use any of the probes while alcohol from disinfection is still on the probe’s surface. Always allow the probes to completely dry before using the probe again.

If skin irritation occurs while using any of the probes, cease probe use immediately.

While soldering any component of this project, always do so in a well ventilated room with a fume hood to prevent the inhalation of toxic fumes. Always wear gloves and safety goggles while soldering to prevent material from coming into contact with exposed skin or eyes. Always wash hands thoroughly after soldering.

2.4 WATER SAFETY

Do not operate this system around water or expose this system to water. This device is not rated for water exposure, and exposure to water carries the risk of damage to the device and the user if the system is operated. If the system is inadvertently exposed to water, immediately unplug the central housing from the power supply. Put on insulating gloves and footwear, then

disconnect the batteries from the sensors in each housing. Before operating again, allow the system to fully dry, and inspect the system to ensure that all water has dried.

2.5 SUBSTANCE SAFETY

Do not operate this system while under the influence on substances that alter coordination or decision making, such as alcohol. Using such substances can cause individuals to ignore other safety considerations, and doing so can result in injury or damage to the device.

2.6 CHILD SAFETY

Do not allow children under the age of eighteen to use this system without adult supervision.

2.7 THERMAL SAFETY

This device contains electrical components that have the ability to get warm during use. When the device is in use, do not attempt to touch the microcontroller or any other electrical component other than the external sensor probe of each sensor module.

Always ensure that a fire extinguisher is nearby when building and operating this device. If smoke is seen rising from any sensor module or housing, disconnect the system from the external power source. If able, move the smoking housing to a safe location away from the rest of the system or anything flammable before attempting to open the system and disconnect the battery.

2.8 EXPLOSION SAFETY

Do not use this device while the housing is not on. This device contains components that have the capability to explode in rare circumstances, namely the capacitors and the batteries. To decrease the risk of being struck by shrapnel in the unlikely event of explosive failure of these components, always operate this device with the proper housing pieces.

2.9 IRRESPONSIBILITY SAFETY

In summary, please exercise caution and common sense when operating this device. If the device is operated in an unsafe manner, there is the potential for dangerous results. Please follow the aforementioned safety guidelines when operating this device.

3.0 ASSEMBLY INSTRUCTIONS

Detailed below are the instructions required to construct the entire system. The first section discussed the printing of all of the housing components. The second section discussed the instructions required to print the PCBs and assemble the PCBS. The third section discusses the assembly of the OLEDs for each sensor module. The fourth section discusses the final assembly of the central Charging Module. The fifth section discusses the final assembly for each of the Sensor Modules. The sixth section discusses the final assembly for the Receiver Module.

3.1 HOUSING INSTRUCTIONS

This section details the procedure for printing the housing for the sensors.

3.1.1 PRINTER REQUIREMENTS

For this, there will be a size requirement due to parts needing to remain in one piece and it would be best to have a printer that has the capacity to handle any of the prints. The printer volume space needs to be at least 330 x 150 x 120 mm with a 0.4mm nozzle extruder. A Prusa XL is recommended.

When printing, set the print setting to “0.10mm FAST DETAIL” for the smaller pieces. This will give them thinner layers and keep them stronger between layers. For the charging station, set the print setting to “0.25mm STRUCTURAL”. As the piece is much larger, this will allow it to print quicker. With this being a storage piece and larger, it does not need to be as tight between the layers.

Even with this amount of space for the smaller pieces, it is recommended to print each piece one at a time as this will allow the print of that piece to be of better quality.

3.2 PCB INSTRUCTIONS

This section details the procedure to create and assemble the PCBs required to operate the sensors.

3.2.1 ORDERING PCBS

The PCB schematic and board files for each sensor are uploaded in the Github repository. The boards that were used for this project were ordered from PCBway. However, any PCB manufacturer is able to replicate these boards. For PCB manufacturers other than PCBway, please refer to their website when ordering.

However, when ordering from PCBway, please refer to this link: https://www.pcbway.com/blog/help_center/How_to_Generate_BOM_and_Centroid_File_in_Eagle_f0fa4189.html, which explains how to extract the Bill of Materials (BOM) and Centroid files. Once these files are extracted, go to the PCBway website and follow the ordering procedures. Simply upload the Gerber files, which can be extracted from EagleCAD, into the PCBway ordering form. The website will then automatically match the specifications of the PCB. Once the board ordering is finalized, proceed to the assembly. Within the assembly, keep all the default options that PCBway has. However, you may change the silkscreen color of the PCBs. For this project, a white silkscreen was chosen.

Once the PCBs are within the ordering page of the PCBway website, this will require for the BOM and centroid files to be uploaded before the user may proceed. Upload the BOM and centroid files, and wait for PCBway to confirm the cost. The user will receive an email and simply check and modify the cost.

3.2.2 CONSTRUCTING PCBS

Below are the walkthroughs for how to construct each of the PCBs should they be ordered empty. In the event that the PCBs are ordered with all of the components already on them, please disregard these instructions.

3.2.2.1 TEMPERATURE PCB

This section outlines the procedures to solder and assemble the Temperature PCB.

TOOLS REQUIRED:

1. One Soldering Iron
2. One Hot Air Gun or Soldering Hot Plate
3. One Set of Tweezers
4. One Soldering Microscope
5. Two Needles or Another Solder Paste Application Tool
6. One Set of Wire Strippers

COMPONENTS:

1. Solder Wire
2. Solder Paste
3. One Empty 100320 Temperature PCB
4. Three 10 kΩ PCB Resistors (0603 size)
5. One 1 kΩ PCB Resistor (0603 size)
6. One Red PCB LED (0603 size)
7. One 0.1 µF Capacitor (0603 size)
8. One 10 µF Capacitor (0603 size)
9. One SJ-3523-SMT-TR 3.5 mm AUX Port
10. One Two-Lead 3.5 mm AUX Jack
11. One Amphenol MA100GG103AN Catheter 10 kΩ Thermistor
12. 2 mm Diameter White Heat Shrink Tubes

PROCEDURE:

1. Perform Steps 1-11 using the Solder Microscope.
2. Using the Two Needles or Another Solder Paste Application Tool, place a small amount of Solder Paste on the pair of solder pads for the “R1,” “R2,” and “R3” components on the 100320 Temperature PCB.
3. Using the Tweezers, place the three 10 kΩ PCB Resistors on the “R1,” “R2,” and “R3” solder pads in contact with the Solder Paste. Ensure that the labels of the 10 kΩ PCB Resistors are face up.
4. Using the Hot Air Gun or Soldering Hot Plate, heat the Solder Paste until it fully melts. Then remove the heat and allow the solder to cool and fuse the three 10 kΩ PCB Resistors to their solder pads. If using the Hot Air Gun, be careful to not blow the resistors off of their pads, using the Tweezers to help hold the resistors in place.
5. Please Proceed to UM 4.1 to generate the resistance values needed for calibration. This is the best place for this calibration to occur, though it can be done later with extra work. When complete, continue with this assembly procedure.
6. Using the Two Needles or Another Solder Paste Application Tool, place a small amount of Solder Paste on the pair of solder pads for the “C1,” “C2,” “R16,” and “D1” components on the 100320 Temperature PCB.
7. Using the Tweezers, place the 10 µF Capacitor on the “C1” solder pads in contact with the Solder Paste. Ensure that the label of the 10 µF Capacitor is face up.
8. Using the Tweezers, place the 0.1 µF Capacitor on the “C2” solder pads in contact with the Solder Paste. Ensure that the label of the 0.1 µF Capacitor is face up.
9. Using the Tweezers, place the 1 kΩ PCB Resistor on the “R16” solder pads in contact with the Solder Paste. Ensure that the label of the 1 kΩ PCB Resistor is face up.
10. Using the Tweezers, place the Red PCB LED on the “D1” solder pads in contact with the Solder Paste. Ensure that the green stripe of the Red LED is facing up and towards the “LED DISABLE”.
11. Using the Hot Air Gun or Soldering Hot Plate, heat the Solder Paste until it fully melts. Then remove the heat and

allow the solder to cool and fuse the components to their solder pads. If using the Hot Air Gun, be careful to not blow the components off of their pads, using the Tweezers to help hold the components in place.

12. Using the Soldering Iron, solder the SJ-3523-SMT-TR 3.5 mm AUX Port onto the 100320 Temperature PCB.
13. Using the Soldering Iron, place Solder onto the solder jumpers “JP1,” “JP2,” “JP3,” and “JP4” to connect the two pads of the jumpers.
14. Using the Wire Strippers, cut the Thermistor wire so that the wires connected to the Thermistor are at least 15 cm long. Then, remove roughly 5 mm of insulation from both of the wires of the Thermistor.
15. Using the Wire Strippers, cut the Two-Lead 3.5 mm AUX Jack wire so that the wires connected to the Jack are at least 15 cm long. Then, remove roughly 0.5 cm of insulation from both of the wires of the Jack.
16. Slip two pieces of the White Heat Shrink Tubes over the two wires of the Thermistor. Be sure to use enough of the Heat Shrink Tubes to cover the wires and solder completely.
17. Using the Soldering Iron, solder the two wires of the Thermistor to the two wires of the Two-Lead 3.5 mm AUX Jack.
18. Slide the Heat Shrink Tubes over the exposed wires and solder.
19. Use the Hot Air Gun to shrink the Heat Shrink Tubes until they are tight around the wires and solder.
20. Using the Hot Air Gun, hit the Heat Shrink Tubes with hot air until the tubes shrink tightly around the soldered wires.
21. Plug the 3.5 mm AUX Jack into the 3.5 mm AUX Port

3.2.2.2 SKIN IMPEDANCE PCB

This section outlines the procedures to solder and assemble the Impedance PCB.

PROCEDURE:

1. Please refer to the PCB ordering section. Due to the complex nature of this PCB, it is not recommended to

micro-solder the components on your own. However, if one does want to microsolder this PCB, the schematic and board files are within the Github page. Download the BOM files from these documents, and follow the orientation using the board.

3.2.2.3 ECG PCB

This section outlines the procedures to solder and assemble the ECG PCB.

TOOLS REQUIRED:

1. One Soldering iron
2. One Hot air gun
3. One Set of Tweezers
4. Two Needles or Another Solder Paste Application Tool
5. One Soldering Microscope

COMPONENTS:

1. Solder Wire
2. Solder Paste
3. One Red LED SMD (0603 size)
4. One 1kΩ resistor SMD (0603 size)
5. One SparkFun Pre-Amplifier ECG board (AD8232 chip)
6. Four M3 x 6 mm Stainless Steel Hex Socket Head Cap Screws
7. Four M3 Nuts
8. Four M3 Plastic Washers

PROCEDURE:

1. Within the PCB, place solder paste on the R16 and D1 pads, you may use the tweezers, needle/pin, and microscope.
2. Using the tweezers, carefully place the 1k ohm resistor on the R16 pads.
3. Using the tweezers, carefully place the Red LED on the D1 pads, with the green label facing the 1k resistor.

4. Carefully, use the hot air gun on its lowest speed and aim it at the SMD components. Using the microscope, observe as the solder paste melts. Use the tweezers to move the components in case it moves from the hot air.
5. Once the SMDs are in place and the solder paste has melted, aim the hot air gun away and turn it off.
6. Solder the header pins that came along with the SparkFun board to the board, ensuring the long side of the pins face downwards.
7. Thread the M3 Screws through the four holes of the SparkFun board.
8. Thread the four M3 Plastic Washers onto the four M3 Screws.
9. Orient the SparkFun board on the PCB. Follow the labels of the PCB and match it with the SparkFun board, ensuring the headers on the SparkFun board go through the pin holes on the PCB and the screws go through the screw holes on the PCB.
10. Screw the M3 Nuts onto the screws, securing the SparkFun board to the PCB.
11. Solder the header pins of the SparkFun board on the PCB through the backside.

3.2.2.4 PULSE OXIMETER PCB

This section outlines the procedures to solder and assemble the Pulse Oximeter PCB.

PROCEDURE:

1. Please refer to the PCB ordering section. Due to the complex nature of the pulse ox PCB and the amount of components it has. it is not recommended to micro-solder the components on your own. However, if one does want to microsolder this PCB, the schematic and board files are within the Github page. Download the BOM files from these documents, and follow the orientation using the board.

3.2.2.5 DIGITAL STETHOSCOPE PCB

This section outlines the procedures to solder and assemble the Digital Stethoscope PCB.

TOOLS REQUIRED:

1. One Soldering Iron
2. One Hot Air Gun or Soldering Hot Plate
3. One Set of Tweezers
4. One Soldering Microscope
5. Two Needles or Another Solder Paste Application Tool

COMPONENTS:

1. Solder Wire
2. Solder Paste
3. One Empty 100420 Sound Sensor PCB
4. Red LED SMD (0603 size)
5. One 1k ohm resistor SMD (0603 size)
6. One 2k ohm resistor SMD (0603 size)
7. Two 7.5k ohm resistors SMD (0603 size)
8. One 20k ohm resistor SMD (0603 size)
9. One 0.1 µF Capacitor SMD (0603 size)
10. One 10 µF Capacitor SMD (0603 size)
11. Two 22 µF Capacitors SMD (0603 size)
12. One TL071ACD (SMD Operational Amplifier)
13. One PCBArtists ES8388 Audio CODEC
14. One Adafruit MAX9814 Microphone
15. Two M3 x 6 mm Stainless Steel Hex Socket Head Cap Screws
16. Two M3 Nuts
17. Two M3 Plastic Washers

PROCEDURE:

1. Within the PCB, place solder paste on the U2 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the TL071ACD on the U2 pad.

2. Within the PCB, place solder paste on the R6 and R7 pads, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the two 7.5 k ohm resistors on each pad.

3. Within the PCB, place solder paste on the C1 and C8 pads, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the two 22 µF capacitors on each pad.

4. Within the PCB, place solder paste on the R9 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the 20k ohm resistor on the R9 pad.

5. Within the PCB, place solder paste on the R10 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the 2k ohm resistor on the R10 pad.

6. Within the PCB, place solder paste on the C6 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the 0.1 µF capacitor on the C6 pad.

7. Within the PCB, place solder paste on the C7 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the 10 µF capacitor on the C7 pad.

8. Within the PCB, place solder paste on the R16 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the 1k ohm resistor on the R16 pad.

9. Within the PCB, place solder paste on the D2 pad, you may use the tweezers, needle/pin, and microscope. Using the tweezers, carefully place the Red LED on the D2 pad.

10. Carefully, use the hot air gun on its lowest speed and aim it at the SMD components. Using the microscope, observe as the solder paste melts. Use the tweezers to move the components in case it moves from the hot air.

11. Once the SMDs are in place and the solder paste has melted, aim the hot air gun away and turn it off.

12. Solder the header pins that came along with the Adafruit MAX9814 board.

13. Thread the M3 Screws through the two holes of the Adafruit MAX9814 board.
14. Thread the two M3 Plastic Washers onto the two M3 Screws.
15. Next, orient the Adafruit MAX9814 board on the PCB. Follow the labels of the PCB and match it with the Adafruit MAX9814 board.
16. Screw the M3 Nuts onto the screws, securing the Adafruit MAX9814 board to the PCB.
17. Solder the header pins of the PCBArtists ES8388 board on the PCB through the backside.
18. Solder the header pins that came along with the PCBArtists ES8388 board.
19. Next, orient the PCBArtists ES8388 board on the PCB. Follow the labels of the PCB and match it with the Adafruit MAX9814 board.
20. Solder the header pins of the PCBArtists ES8388 board on the PCB through the backside.

3.3 OLED INSTRUCTIONS

Below are the procedures needed to prepare the five OLEDs for assembly into the system. The OLED fits tightly into the slot within the Sensor Housing, so when soldering, ensure that the wires are straight out of their holes and that minimal solder is used. Hot glue is applied after soldering to secure the wires in place.

TOOLS REQUIRED:

1. One Soldering Iron
2. One Fine-Grain File
3. One Set of Wire Strippers
4. Hot Glue Gun

COMPONENTS:

1. Solder Wire
2. Hot Glue
3. Hot Glue
4. One 100210 Module Bottom

5. One 100220 Module Top
6. Five Frienda 0.91 Inch 128 x 32 pixels I2C DC 3.3V~5V OLED Display Module
7. Five Stemma QT / Qwiic JST SH 1 mm 4-pin to Male Connectors

PROCEDURE:

1. Using the Wire Strippers, cut the Stemma QT Connector roughly 5 cm above the JST-SH 4-pin Female Connector.
2. Using the Wire Strippers, remove roughly 2 mm of insulation off of the wires connected to the JST-SH 4-pin Female Connector.
3. Using the Soldering Iron, solder the Black Wire of the JST-SH 4-pin Female Connector to the GND hole of the OLED.
4. Using the Soldering Iron, solder the Red Wire of the JST-SH 4-pin Female Connector to the VCC hole of the OLED.
5. Using the Soldering Iron, solder the Yellow Wire of the JST-SH 4-pin Female Connector to the SCL hole of the OLED.
6. Using the Soldering Iron, solder the Blue Wire of the JST-SH 4-pin Female Connector to the SDA hole of the OLED.
7. Using the Hot Glue Gun, glue the wires soldered to the OLED where the wires are soldered and where the bare wire is exposed to ensure the wires cannot bend and break.
8. Attempt to fit the soldered OLED into the Sensor Module, parts 100210 and 100220.
9. If the OLED does not fit, use the file to remove solder from connections.
10. Repeat Step 7 and Step 8 until the OLED fits within the housings.
11. Repeat Steps 1-10 for the four other OLEDs.

3.4 FINAL CHARGING MODULE ASSEMBLY

This section details the procedure required to construct the charging station. The construction of the station includes adding pieces that are not required for the station to operate but do allow transportation to proceed with greater ease.

TOOLS REQUIRED:

1. Scissors

2. Hot Glue Gun

COMPONENTS:

1. Hot Glue
2. Sticky Velcro Pads
3. One Surge Protector with at least Five USB-A
4. Five Magnetic Charging Cables
5. One 100250 Charging Station Main Body
6. One 100260 Charging Station Base

PROCEDURE:

1. Taking the opposite sides of the velcro, peel off the plastic coating the sticky side of the hooks and stick to the bottom of the surge protector. If the pad is too large, cut to size after sticking.
2. Take the hoops side and cut to size to fit within the Charging Module; this can be approximated. Remove the plastic covering on the sticky side and attach to the Charging Station Base plate.
3. Attach the surge protector to the Charging Station Base plate.
4. Insert the magnetic charging cables into the surge protector.
5. Put the cables through the holes in the top of the Charging Station Main Body and secure them so as not to have them fall through.
6. With the Hot Glue Gun, put a small glob in the holes where the cables are in, try not to put them on the cables directly.
7. Pull the cables slowly into the holes and secure them so the magnetic face is flush with the radius of the hole.
8. After the glue stiffens, push the Charging Station Main Body onto the Charging Station Base plate until a click is heard.

3.5 FINAL SENSOR MODULE ASSEMBLY

This section details the procedure required to construct the five Sensor Modules. As for the most part, the components within the system are interchangeable, these instructions will be generalized for the modules as a whole; charts will be included to describe sensor-specific instructions, where required.

TOOLS REQUIRED:

1. One Soldering Iron

2. One Set of Wire Strippers
3. Hot Glue Gun
4. One 2.5 mm Allen Wrench
5. One 1.5 mm Allen Wrench
6. One Laptop with the Arduino IDE, required Codes, and a USB-A Port
7. One USB-A to USB-C Cable

COMPONENTS:

1. Solder Wire
2. Hot Glue
3. Five 100210 Module Bottoms
4. Five 100220 Module Tops
5. One Assembled 100320 Temperature PCB
6. One Assembled 100420 Sound Sensor PCB
7. One Assembled 100520 Pulse Oximeter PCB
8. One Assembled 100620 Skin Impedance PCB
9. One Assembled 100720 ECG PCB
10. 100330 Temperature Arduino Code
11. 100430 Sound Sensor Arduino Code
12. 100530 Pulse Oximeter Arduino Code
13. 100630 Skin Impedance Arduino Code
14. 100730 ECG Arduino Code
15. One 100340 Temp Insert
16. One 100460 Sound Insert
17. One 100540 Pulse Ox Insert
18. One 100650 Impedance Insert
19. One 100750 ECG Insert
20. Five Adafruit 5323 ESP32-S3 Feathers

21. Five Assembled I2C OLEDs
22. Five B07V9P5LGB Magnetic Charging Tips
23. Five 1009 Tactile Buttons
24. Five Adafruit 258 3.3 V 1200 mAh Batteries
    a. Note: If using batteries that are not Adafruit Brand and microcontrollers that are not Adafruit Brand, please check the polarity of both the battery and the battery plug on the microcontroller. Adafruit batteries and microcontrollers reverse the polarities of the terminals to connect the battery to the microcontroller. If a battery does not have the same polarity as the microcontroller being used, it has the potential to destroy the battery, the microcontroller, or both.
25. Twenty M3 x 6 x 5 mm Female Thread Brass Knurled Threaded Insert Embedment Nuts
26. Twenty M3 x 6 mm Stainless Steel Hex Socket Head Cap Screws
27. Twenty M3 Nuts
28. Ten M2 x 4 x 3.5 mm Female Thread Brass Knurled Threaded Insert Embedment Nuts
29. Ten M2 x 16 mm Steel Flat Head Hex Socket Cap Screws
30. Ten M2 Plastic Washers
31. Twenty M2 Nuts
32. Five 10 kΩ Breadboard Resistors
33. Assorted 20 AWG Wires of Colors in Figures 3.5.2-3.5.6

PROCEDURE:

1. Using the Soldering Iron, gently melt the sides of the empty screw holes for the PCB of the 100220 Module Top.
2. Insert the M3 x 6 x 5 mm Brass Nut into the hole, then push the Brass Nut into the hole until it is flush using the hot Soldering Iron. Be careful to not burn through the other side of the housing with the Soldering Iron.
3. Repeat Step 1 and Step 2 for the other three holes of the 100220 Module Top.
4. Repeat Steps 1-3 for the two empty screw holes for the ESP32 of the 100210 Module Bottom with the M2 x 4 x 3.5 mm Brass Nuts.

5. For the Sensor Module being built in Figure 3.5.1, use the Laptop and the USB-A to USB-C Cable to load the correct code onto an ESP32-S3. To do this, connect the ESP32-S3 to the Laptop with the Cable, and using the Arduino IDE, load the code being used for the Sensor Module being built. To prepare the ESP32-S3 for the code, press and hold the "Boot Button" on the ESP32-S3, then press the "Reset Button," then release the "Boot Button." On the top of the IDE, select the "Adafruit Feather ESP32-S3 No PSRAM" microcontroller from the menu and select the correct COM port the ESP32-S3 is connected to. Press the "Upload Button" on the top of the IDE, and wait for the Output to display that the upload is complete.

6. Disconnect the USB-A to USB-C Cable from the ESP32-S3, then plug the B07V9P5LGB Magnetic Charging Tip into the ESP32-S3.

7. For the Sensor Module being built in Figure 3.5.1, use the relevant wiring guide in Figures 3.5.2-3.5.6 and the Soldering Iron to solder the Tactile Button and the PCB to the ESP32-S3. Be careful to not burn any of the components on the ESP32-S3 or the PCB. Ensure that the wires used are at least 10 cm long to ensure the wires are long enough to allow for the Sensor Module to be opened without tearing out the wires.

    a. If two components have wires that need to connect to the same hole on the ESP32-S3, such as how both the Temperature PCB and the Tactile Button require a connection to the 3V hole on the ESP32-S3, it is suggested that you solder the wires that connect to the PCB and the Tactile button first. Afterwards, take the leads from both components, twist the uninsulated ends that are meant to connect to the ESP32-S3 together, then solder the braided wire to ESP32-S3. This way, both wires are soldered at once, and they will hopefully have a stronger connection to the ESP32-S3.

    b. When connecting the Black Lead of the Tactile Button to GND, solder a 10 kΩ Breadboard Resistor to the pin of the Tactile Button, then solder the Black Lead to the other end of the resistor. Then solder the other end of the wire connected to the resistor to the GND hole of the ESP32-S3. This resistor is involved in logic, and is required for proper button function.

8. Using the Hot Glue Gun, glue the wires soldered to the ESP32-S3, PCB and Tactile Button where the wires are soldered and where the bare wire is exposed to ensure the wires cannot bend and break.

9. For the Sensor Module being built in Figure 3.5.1, thread the M3 x 6 mm Screw through the screw hole on the Assembled PCB, then screw the M3 Nut onto the screw, securing the screw to the PCB. Repeat for the four screw holes on the PCB.

10. Using the 2.5 mm Allen Wrench, screw the PCB onto the 100220 Module Top. Tighten the four screws until the PCB is secure and cannot move. Ensure the probe connection is on the side of the Module Top that has the Probe Slot.

11. Take the M2 x 16 mm Screw and thread an M2 Nut onto the screw. Then thread the screw through one of the screw holes by the USB-C connector on the ESP32-S3. Afterwards, thread an M2 Plastic Washer onto the screw, then thread another M2 Nut onto the screw. Repeat this process for the other screw hole by the USB-C connector on the ESP32-S3.

12. Using the 1.5 mm Allen Wrench, screw the ESP32-S3 onto the 100210 Module Bottom. Tighten the two screws until they are fully in their holes, then tighten the M2 Nuts on top of the ESP32-S3 until the ESP32-S3 is secure and cannot move.

13. Slot the Tactile Button into its space in the 100210 Module Bottom, ensuring that the small nub on the Tactile Button slides into the slot in the Tactile Button space. Ensure that the wires do not disconnect while inserting the Tactile Button.

14. Slide the Assembled I2C OLED into its slot in the 100210 Module Bottom. Ensure that none of the wires do not disconnect while inserting the OLED.

15. Plug the JST-SH 4-pin Female Connector of the Assembled I2C OLED into the JST-SH 4-pin Male Connector on the ESP32-S3.

16. Using the Hot Glue Gun, glue the Adafruit 3.3 V 1200 mAh Battery to the battery space on the 100210 Module Bottom. Ensure the wires of the battery go through the small slot in the battery space. Allow the glue to set.

17. Plug the battery into the battery connector on the ESP32-S3.

18. Remove the probe from the PCB.

19. For the Sensor Module being built in Figure 3.5.1, slide the Cover Slip into the Probe Slot. Ensure the hole in the Cover Slip lines up with the probe connection on the PCB, and that the label on the Cover Slip faces out.

20. Plug the probe back into the PCB.

21. To close the Sensor Module, bring the connectors for the 100210 Module Bottom and 100220 Module Top together. Ensure the Tactile Button, I2C OLED, Magnetic Charging Tip, and the Cover Slip slide into their corresponding slots in both housings without breaking any wires or components. Be very careful with the OLED especially. Once done, press

the two halves of the housings together until you hear the Sensor Module close, beginning with the OLED side of the Sensor Module.

22. Repeat Steps 1-21 for all other Sensor Modules you wish to construct.

PARTS CHARTS:

FIGURE 3.5.1: SENSOR-SPECIFIC PARTS			
Sensor Module	**Assembled PCB**	**Code**	**Cover Slip**
Temperature	**100320**	**100330**	**100340**
Sound Sensor	**100420**	**100430**	**100460**
Pulse Oximeter	**100520**	**100530**	**100540**
Skin Impedance	**100620**	**100630**	**100650**
ECG	**100720**	**100730**	**100750**

FIGURE 3.5.2: TEMPERATURE SENSOR WIRING LIST			
ESP Hole	**PCB Hole**	**Tactile Button**	**Wire Color**
3V	**3V**	**1**	**Red**
GND	**GND**	**4**	**Black with 10 kΩ Pull-down Resistor for the Tactile Button**
A0	**A0**		**Green**
A1	**A1**		**Blue**
10		**4**	**Yellow**

FIGURE 3.5.3: SOUND SENSOR WIRING LIST			
ESP Hole	**PCB Hole**	**Tactile Button**	**Wire Color**
3V	**3V**	**1**	**Red**
GND	**GND**	**4**	**Black with 10 kΩ Pull-down Resistor**

			for the Tactile Button
DGND	**3V (1st pin)**		**Black**
DVDD	**GND**		**Red**
AGND	**3V (2nd pin)**		**Black**
AVDD	**GND**		**Red**
SDA	**SDA**		**Green**
SCL	**SCL**		**Green**
MCLK	**A4**		**Yellow**
SCLK	**SCK**		**Yellow**
LRCLK	**A5**		**White**
DIN	**MO**		**Blue**
DOUT	**MI**		**Blue**
10		**4**	**Yellow**

FIGURE 3.5.4: PULSE OXIMETER SENSOR WIRING LIST			
ESP Hole	**PCB Hole**	**Tactile Button**	**Wire Color**
3V	**VCC**	**1**	**Red**
GND	**GND**	**4**	**Black with 10 kΩ Pull-down Resistor for the Tactile Button**
A4	**START**		**WHITE**
13	**RDY**		**WHITE**
6	**CS0**		**YELLOW**
MI	**MOSI**		**YELLOW**
MO	**MISO**		**YELLOW**

SCK	**SCK**		**YELLOW**
NC	**PD ALM**		
NC	**LED ALM**		
NC	**DIAG END**		
5	**PWDN**		**WHITE**
10		**4**	**RED**

FIGURE 3.5.5: SKIN IMPEDANCE SENSOR WIRING LIST			
ESP Hole	**PCB Hole**	**Tactile Button**	**Wire Color**
SDA	**SDA**		**Blue**
SCL	**SCL**		**Yellow**
GND	**GND**	**4**	**Black with 10 kΩ Pull-down Resistor for the Tactile Button**
3V	**3v3**	**1**	**Red**
9		**4**	**Red**
12	**CAL_INT**		**White**

FIGURE 3.5.6: ECG SENSOR WIRING LIST			
ESP Hole	**PCB Hole**	**Tactile Button**	**Wire Color**
3V	**3.3V**	**1**	**Red**
GND	**GND**	**4**	**Black with 10 kΩ Pull-down Resistor for the Tactile Button**
11	**LO-**		**Blue**
10	**LO+**		**White**
9		**4**	**Yellow**

A1	**OUTPUT**		**Green**

3.6 FINAL RECEIVER MODULE ASSEMBLY

This section details the procedure required to construct the Receiver Module. Only one Receiver Module is needed for each complete system.

TOOLS REQUIRED:

1. One Soldering Iron
2. One 1.5 mm Allen Wrench
3. One Laptop with the Arduino IDE, required Codes, and a USB-A Port

COMPONENTS:

1. One 100230 Receiver Bottom
2. One 100240 Receiver Top
3. 100130 Receiver Code
4. One Adafruit 5323 ESP32-S3 Feather
5. Two M2 x 4 x 3.5 mm Female Thread Brass Knurled Threaded Insert Embedment Nuts
6. Two M2 x 16 mm Steel Flat Head Hex Socket Cap Screws
7. Two M2 Plastic Washers
8. Four M2 Nuts
9. One USB-A to USB-C Cable

PROCEDURE:

1. Using the Soldering Iron, gently melt the sides of the empty screw holes for the ESP32-S3 of the 100230 Receiver Bottom.
2. Insert the M2 x 4 x 3.5 mm Brass Nut into the hole, then push the Brass Nut into the hole until it is flush using the hot Soldering Iron. Be careful to not burn through the other side of the housing with the Soldering Iron.
3. Repeat Step 1 and Step 2 for the other hole of the 100230 Module Bottom.
4. Use the Laptop and the USB-A to USB-C Cable to load the Receiver Code onto an ESP32-S3. To do this, connect the ESP32-S3 to the Laptop with the Cable, and using the Arduino IDE, load the Receiver Code. To prepare the ESP32-S3 for the code, press and hold the “Boot Button” on the

ESP32-S3, then press the “Reset Button,” then release the “Boot Button.” On the top of the IDE, select the “Adafruit Feather ESP32-S3 No PSRAM” microcontroller from the menu and select the correct COM port the ESP32-S3 is connected to. Press the “Upload Button” on the top of the IDE, and wait for the Output to display that the upload is complete.

5. Disconnect the USB-A to USB-C Cable from the ESP32-S3 and the Laptop.

6. Take the M2 x 16 mm Screw and thread an M2 Nut onto the screw. Then thread the screw through one of the screw holes by the USB-C connector on the ESP32-S3. Afterwards, thread an M2 Plastic Washer onto the screw, then thread another M2 Nut onto the screw. Repeat this process for the other screw hole by the USB-C connector on the ESP32-S3.

7. Using the 1.5 mm Allen Wrench, screw the ESP32-S3 onto the 100230 Receiver Bottom. Tighten the two screws until they are fully in their holes, then tighten the M2 Nuts on top of the ESP32-S3 until the ESP32-S3 is secure and cannot move.

8. To close the Receiver Module, bring the connectors for the 100230 Receiver Bottom and 100240 Receiver Top together. Once done, press the two halves of the housings together until you hear the Receiver Module close.

9. Plug the Cable back into the ESP32-S3 within the Receiver Module.

4.0 CALIBRATION INSTRUCTIONS

This section contains the calibration procedures for the Temperature Module and the Skin Impedance Module.

4.1 TEMPERATURE MODULE CALIBRATION

In order for the Temperature Module to be accurate, a simple calibration procedure must be completed. It is recommended that this procedure be completed after Step 4 of Procedure 3.2.2.1. It is recommended to keep the resistor values gained through this calibration with the Temperature Module at all times. Consider keeping the resistor values on a sticky note on the Temperature Module, or at least with the system as a whole, especially if more than one system is present at a location.

TOOLS REQUIRED:

1. One Digital Multimeter capable of measuring up to 10 kΩ of resistance and detecting continuity

2. One Precision Knife or other sharp, small cutting implement

3. One Soldering Iron with thinly beveled tip adequate for use on a PCB

4. One 2.5 mm Allen Wrench

COMPONENTS:

1. Solder Wire

PROCEDURE:

1. Unplug the temperature probe from the 3.5 mm port, if plugged in.
2. Using the 2.5 mm Allen Wrench, remove the temperature PCB from the housing, if it is in the housing.
3. Using the Soldering Iron, desolder the solder jumpers, labeled “JP1,” “JP2,” “JP3,” and “JP4,” if soldered.
4. Using the Precision Knife, slice the thin strip of metal connecting the two pads within the box labeled “LED DISABLE.” If the “LED DISABLE” is soldered instead, desolder it using the Soldering Iron.
5. To measure the resistance of “R1,” connect the two leads of the Digital Multimeter to “TP1” and “TP4.”
6. Ensure the resistance value is close to 10 kΩ. If it is, record the given resistance value. If it is not, ensure all solder jumpers are completely desoldered and the “LED DISABLE” is completely cut and desoldered, and remeasure.
7. To measure the resistance of “R2,” connect the two leads of the Digital Multimeter to “TP1” and “TP2.”
8. Repeat Step 5.
9. To measure the resistance of “R3,” connect the two leads of the Digital Multimeter to “TP2” and “TP3.”
10. Repeat Step 5.
11. Using the Soldering Iron, place a small amount of Solder onto the solder jumpers to connect the two pads of each jumper.
12. Using the Soldering Iron, place a small amount of Solder onto the “LED DISABLE” pads to connect the two pads of the “LED DISABLE.”
13. Using the Digital Multimeter, place the two leads on both of the pads of the “JP1,” “JP2,” “JP3,” “JP4,” and the “LED DISABLE” solder jumpers and measure the continuity of the jumpers. If any of the jumpers are not continuous, repeat Step 11, Step 12, and Step 13.

4.2 SKIN IMPEDANCE MODULE CALIBRATION

This section is concerned with the Calibration Procedure of the Skin Impedance Module.

PROCEDURE:

1. Refer to Step 3 of UM 5.6.

4.3 SOUND SENSOR MODULE CALIBRATION

This section is concerned with the Calibration Procedure of the Digital Stethoscope Module.

COMPONENTS:

1. Solder Wire
2. Solder Iron

PROCEDURE:

1. With the PCB properly soldered to the ESP32, open the code for the Sound Sensor (100430).
2. Uncomment lines 43, 44, 92, 93, and 110. Comment line 111.
3. Upload the code to the ESP32 and open the serial plot feature of Arduino IDE.
4. Verify the signal amplitude. The normal amplitude for the signal values go from -32768 to 32767. However, due to both the analog and digital filters, the maximum amplitude (and therefore the relative amplitude of the other samples) may decrease.
5. The PCB includes the SET_GAIN port. If none of the pins are connected to each other, the MAX9814 preamplifier will have a gain of 60 dB. If pins Gain and Gnd are connected, the preamplifier will have a gain of 50 dB. If pins Gain and Vdd are connected, the preamplifier will have a gain of 40 dB. Select the configuration of your preference.
6. Solder a wire that connects the pins of your preference.
7. In the Sound Sensor code (100430), comment lines 43, 44, 92, 93, and 110. Uncomment line 111.
8. Upload the altered code to the ESP32.

5.0 USE INSTRUCTIONS

This section of the User Manual describes the procedures to use the system. This section will describe how to charge the Sensor Modules, how to operate the GUI, how to use each Sensor Module, and how to properly shutdown the system; however, before going over example use instructions, general system function and features will first be explained.

5.1 SYSTEM FUNCTION & FEATURES

This system is a modular biomedical sensor array. Each sensor probe and sensor PCB measures a different biological signal, which is then processed in each sensor's ESP32-S3 into a measurement. That measurement is then displayed onto the Sensor Module's OLED and is broadcast to the Receiver Module. The Receiver Module then takes the data sent by the module and returns it to the GUI operating on the User's Laptop. The GUI can be set to display and record incoming data for one sensor at a time. Once the module is no longer needed, the module can be returned to the Charging Module; magnetic connectors on the Sensor Modules and the Charging Module allow for the Sensor Modules to charge without needing to deal with wires.

There are seven total modules in the system. There are five Sensor Modules, one Receiver Module, and one Charging Module. All modules can be separated from each other. The main module is the Charging Module, and all other modules can be connected and disconnected from it. The Sensor Modules are designed to be identical, meaning that any Sensor Module can fit in the space for any other Sensor Module. The Receiver Module has its own dedicated slot towards one end of the Charging Module. There is a trough on the side of the Charging Module where the probes from the Sensor Modules can rest when not in use. It is recommended to wrap the probes in a plastic bag, string, or other material when being stored to keep the probes compact and neat.

Each Sensor Module is outfitted with an OLED, a Tactile Button, and a deepsleep mode. The OLED has two main screens when operating. One screen displays the battery life and usage of the module; the other screen displays the current sensor reading for that module. The two screens can be cycled between by pressing the Tactile Button on the side of the module. The deepsleep mode is present to prevent the module from operating and to allow the module to charge faster. It is recommended that this feature be activated when returning the module to the Charging Module and want the Sensor Module to charge. To activate the deepsleep function, press and hold the Tactile Button down for five seconds until the OLED displays "Entering Deepsleep." When you want to use the Sensor Module again, press the Tactile Button again. While the deepsleep function is handy for accelerating charging times or for temporarily not using the module, for longer periods of disuse where the module is not charging or if the module is already nearly fully charged, it is still recommended that the battery be fully disconnected from the ESP32-S3.

The GUI for the system is designed to run on the Laptop of the User. The GUI takes values from the Receiver Module through a USB-A to USB-C Cable. The GUI opens by taking a username from the User, which the GUI uses to create a folder and save the generated data to. Each sensor has its own page within the GUI to operate the sensor and record data. These pages can be navigated to from the Home Screen of the GUI. From there, each sensor can be told to display readings or record those readings to a file on the User's Laptop; buttons controlling when

to display and record data are located in the upper-left of the GUI. Based on the sensor, the data will be displayed in a graph on the page, while some other measurements will be generated and also displayed. Certain sensors will require calibrations to function properly, which are located in the upper-right of the GUI. After ending the current readings, a button in the top part of the GUI can be used to navigate back to the Home Screen. Should the User wish to operate the GUI in "Light Mode" as opposed to the default of "Dark Mode," a toggle switch on the left side of the screen can be used to switch between the two.

5.2 SYSTEM SETUP

This procedure describes the process of starting the system.

PROCEDURE:

1. Plug the Charging Module into an external power supply, such as a wall outlet.
2. Open each Sensor Module and plug the battery into the ESP32-S3, then close the Sensor Module.
3. Press and hold Tactile Button for five seconds until the OLED displays "Entering Deepsleep." Repeat this process for each module. This puts the modules into deepsleep, and will cause them to charge faster than they would when fully operating. Do not leave the system unattended.
4. Return each Sensor Module to the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging Wires of the Charging Module.
5. Plug the Receiver Module into the User's Laptop using the USB-A to USB-C Cable.
6. Open the GUI file on the User's Laptop.
7. When the GUI opens, enter the filename where you wish to save data to in the "Enter Username" box. Please do not use a preexisting folder, as the code will delete everything in the folder in order to save data.
8. Press the "Enter" button.
9. On the Home Page, use the COM Port dropdown menu to select the COM Port the Receiver Module is connected to. The only COM Ports to appear in this menu are the COM Ports actively in use, so if you do not know which port the Receiver Module is connected to, unplug all devices other than the Receiver Module connected to the USB-A ports of the User's Laptop, then return to the dropdown menu. The devices can be plugged back in once the Receiver Module COM Port is selected.
10. Record which COM Port the Receiver Module connected to. The Receiver Module generally should not change COM Ports between use, so

recording this information can make future uses easier. If it does change COM Ports, repeat Step 9.

11. The system is now ready for use.

5.3 TEMPERATURE MODULE OPERATION

This section outlines the procedure to utilize the Temperature Module.

PROCEDURE:

1. On the Sensor Selection Page of the GUI, press the “Temperature Sensor” button.
2. Press the Tactile Button on the Temperature Module to wake the module from deep sleep.
3. To calibrate the Temperature Module, enter the recorded resistor values from Procedure 4.1 into the “Resistor Value” boxes in the upper-right corner of the GUI. After entering each value, press the “Send Resistor” button.
4. Verify that the new resistor values are sent. Using the Tactile Button, navigate to the page of the OLED on the Temperature Module that displays the temperature reading and resistor values. If the values displayed are not the values sent, repeat Step 3.
5. Unwrap the probe.
6. Place the probe within or in contact with the material or individual being measured. If using without the GUI, the temperature reading can be viewed on the OLED of the Temperature Module.
7. Press the “Start Reading Data” button on the GUI to begin displaying data on the GUI.
8. Press the “Start Saving Data” button on the GUI to begin saving readings to the User’s Laptop, if you wish to save data to the Laptop.
9. Press the “Stop Saving Data” button on the GUI to stop saving data, if the system was currently saving data.
10. Press the “Stop Reading Data” button on the GUI to finish reading data from the sensor to the GUI.
11. When finished with the Temperature Module, press the “MediBrick 2000 Home" button on the GUI to return to the Home Page. Press and hold the Tactile Button on the Temperature Module for five seconds to place the module back into deep sleep. Wrap the probes as they were before. Return the module to the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging

Wires of the Charging Module. Place the wrapped probes back into the trough on the side of the device.

5.4 SOUND SENSOR MODULE OPERATION

This section outlines the procedure to utilize the Sound Sensor Module to listen to the heartbeat and lung sounds.

PROCEDURE:

1. Upload the sound sensor receiver code (100431) to the receiver ESP32 and match the MAC addresses of both ESP32's (sender and receiver).
2. Open the sound sensor module and connect the battery to turn it on. Close it carefully.
3. Plug the stethoscope tubes into the sound sensor module.
4. On the Sensor Selection Page of the GUI, press the "Digital Stethoscope" button.
5. Press the "Start Reading Data" button on the GUI to begin displaying data on the GUI.
6. Place the stethoscope diaphragm in the desired position on the chest on the subject to listen to their heartbeats or lung sounds.
7. You can view the graph of the incoming signal. Activate at will (or deactivate) the "Live Audio Mode" to listen to the incoming signal.
8. Press the "Start Saving Data" button on the GUI to begin saving readings to the User's Laptop, if you wish to save data to the Laptop as an excel file.
9. Press the "Stop Saving Data" button on the GUI to stop saving data, if the system was currently saving data.
10. Press the "Start Recording" button on the GUI to begin saving readings to the User's Laptop as a .wav audio file.
11. Press the "Stop Recording" button on the GUI to stop saving data, if the system was currently saving data.
12. Press the "Stop Reading Data" button on the GUI to finish reading data from the sensor to the GUI.

13. When finished with the Sound Sensor sensor, press the “MediBrick 2000 Home" button on the GUI to return to the Home Page.
14. Carefully, disconnect the stethoscope tubes from the sound sensor module.
15. Open the sound sensor module and carefully disconnect the battery. Close it.
16. Upload the Master Receiver Code (100130) to the receiver ESP32.

5.5 PULSE OXIMETER MODULE OPERATION

This section outlines the procedure to utilize the Pulse Oximeter Module to measure blood oxygen and heart rate.

PROCEDURE:

1. On the Sensor Selection Page of the GUI, press the “Pulse Oximeter” button.
2. Press the Tactile Button on the Pulse oxi Module to wake the module from deepsleep.
3. Place the Pulse Oximeter sensor probe on your index finger.
4. Verify that initialization is done using the OLED display when it displays “init” initialization is done when battery life is displayed.
5. If using without the GUI, the heart rate and blood oxygen reading can be viewed on the OLED of the Pulse OXI module by pressing the main button one time.
6. Press the “Start Reading Data” button on the GUI to begin displaying data on the GUI.
7. You can view the plethysmograph at the bottom of the GUI and heart rate, SPO2 at the top.
8. Press the “Start Saving Data” button on the GUI to begin saving readings to the User’s Laptop, if you wish to save data to the Laptop.
9. Press the “Stop Saving Data” button on the GUI to stop saving data, if the system was currently saving data.
10. Press the “Stop Reading Data” button on the GUI to finish reading data from the sensor to the GUI.

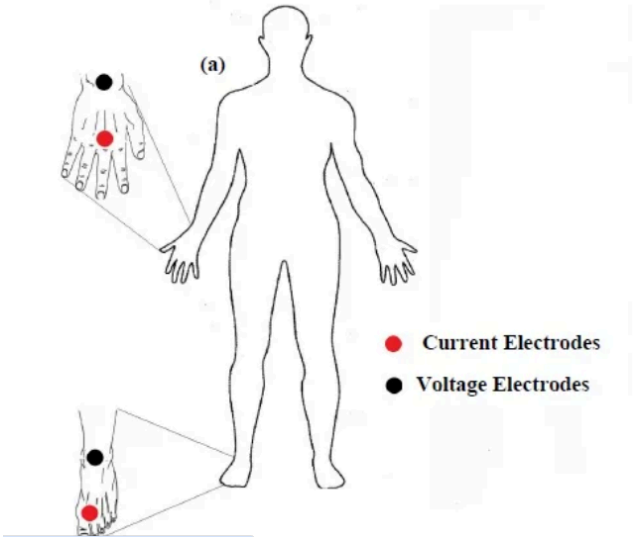
11. When finished with the Pulse Ox sensor, press the “MediBrick 2000 Home" button on the GUI to return to the Home Page. Press and hold the Tactile Button on the Pulse Ox Module for five seconds to place the module back into deep sleep. Place the pulse oxi sensor probe on the “bucket”. Return the module to the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging Wires of the Charging Module.

5.6 SKIN IMPEDANCE MODULE OPERATION

This section outlines the procedure to utilize the Skin Impedance Module to measure Body Fat and Water Content

PROCEDURE:

1. On the Sensor Selection Page of the GUI, press the “Skin Impedance Sensor” button.
2. Press the Tactile Button on the Impedance Module to wake the module from deep sleep.
3. To calibrate the Impedance Module, enter the Height, Weight, and Sex of the User, then click on the calibration button on the GUI.
4. Unwrap the two electrode wires.
5. Prepare 4 skin electrode pads. Place two electrodes on the dorsal side of the right hand. Then place the other electrodes on the dorsal side of the right foot. Check the diagram below.



6. Following the diagram, connect the electrode wires. If using without the GUI, the impedance reading can be viewed on the OLED of the Impedance Module.

7. Press the “Start Reading Data” button on the GUI to begin displaying data on the GUI.

8. Press the “Start Saving Data” button on the GUI to begin saving readings to the User’s Laptop, if you wish to save data to the Laptop.

9. Press the “Stop Saving Data” button on the GUI to stop saving data, if the system was currently saving data.

10. Press the “Stop Reading Data” button on the GUI to finish reading data from the sensor to the GUI.

11. When finished with the Impedance Module, press the “MediBrick 2000 Home" button on the GUI to return to the Home Page. Press and hold the Tactile Button on the Impedance Module for five seconds to place the module back into deep sleep. Wrap the probes as they were before. Return the module to the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging Wires of the Charging Module. Place the wrapped probes back into the trough on the side of the device.

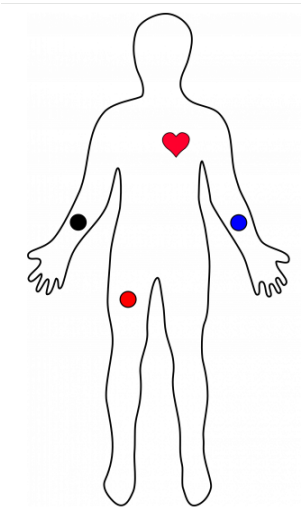
5.7 ECG MODULE OPERATION

1. On the Sensor Selection Page of the GUI, press the “Electrocardiogram” button.

2. Press the Tactile Button on the ECG Module to wake the module from deep sleep.

3. Unwrap the electrode wires.

4. Prepare 3 skin electrode pads. Place one electrode on each ventral side of the wrists. Then place the other electrode on the right leg as ground. Refer to the diagram below for the electrode placement.



5. Following the diagram, connect the electrode wires. If using without the GUI, the ECG reading can be viewed on the OLED of the ECG Module.
6. Press the “Start Reading Data” button on the GUI to begin displaying data on the GUI.
7. Press the “Start Saving Data” button on the GUI to begin saving readings to the User’s Laptop, if you wish to save data to the Laptop.
8. Press the “Stop Saving Data” button on the GUI to stop saving data, if the system was currently saving data.
9. Press the “Stop Reading Data” button on the GUI to finish reading data from the sensor to the GUI.
10. When finished with the ECG Module, press the “MediBrick 2000 Home" button on the GUI to return to the Home Page. Press and hold the Tactile Button on the ECG Module for five seconds to place the module back into deep sleep. Wrap the probes as they were before. Return the module to the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging Wires of the Charging Module. Place the wrapped probes back into the trough on the side of the device.

5.8 SYSTEM SHUTDOWN

This section outlines the procedures for shutting down the system. These procedures should be followed whenever the User has finished using the system. Not following these shutdown procedures has the potential to decrease the lifetime of the device or cause catastrophic failure.

PROCEDURE:

1. Close out of the GUI.
2. Unplug the Charging Module from the external power supply.
3. Unplug the Receiver Module from the Laptop and return the module to the Charging Module.
4. Open each Sensor Module and unplug the battery from the ESP32-S3, then close the Sensor Module.
5. Wrap each sensor probe, then place the wrapped sensor probe in a plastic bag, string, or other material to ensure the probe stays compact.
6. Place the Sensor Module back on the Charging Module, ensuring that the Magnetic Charging Tips of the Sensor Modules align and attach to the Magnetic Charging Wires of the Charging Module. Place the wrapped probes back into the trough on the side of the device.