

Personal Air Monitor



OPERATION MANUAL

Model PAM
Optional CarTopper™
Optional Enclosure

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Contents

IDENTIFICATION RECORDS	iv
PRINTING HISTORY	v
WARRANTY STATEMENT	vi
Warranty Period	vi
Warranty Service	vi
Shipping.....	vi
Conditions.....	vii
Limitation of Remedies and Liability	vii
WARNINGS	viii
UNPACKING THE SHIPPING BOX	ix
Shipping Box Contents	ix
A. Overview: Personal Air Monitor (PAM) Sensor Measurements	1
B. Startup of the PAM	4
B.1 Initial Check of the PAM	4
B.2 The PAM's micro-SD Data Card	6
B.3 Power Up and Begin Test Measurements	6
C. Data Viewing and Downloading with the PAM	7
C.1 Web Data Access on the 2B Tech Portal (via WiFi and/or cellular)	7
C.1.1 Login to the 2B Tech Data Portal	7
C.1.2 Viewing the Data	8
C.1.3 Organizing Your Instruments.....	10
C.1.4 Viewing/Comparing Data from Different Instruments	10
C.1.5 Troubleshooting.....	11
C.2 Accessing the PAM's Micro-SD (µSD) Card Data	12
C.3 USB to Computer or Data Logger	14
C.3.1 Serial Commands.....	15
C.3.2 Serial Data String	17
C.4 Real-Time Data Viewing with Smartphone Application	18
C.4.1 Previous App: "AQTreks"	18
C.4.2 New App: "2B Connect"	18
D. Initialize Settings and Begin Measurements	20
D.1 Clock Settings	20

D.1.1	Enter a Time Zone (to Output Local Time in the Data)	20
D.1.2	To Set the Clock Manually	20
D.2	Set the Data Upload Frequency of the PAM	21
D.3	Establish the PAM's Cellular Connection (if option purchased)	21
D.4	Connect to a WiFi Network	22
D.5	Power Up and Begin Measurements	23
E.	Periodic Zero Checks and Calibration	24
E.1	Zeroing and Calibration of the PAM	24
E.2	Recommended: Frequent Checks of the PAM Sensor Functioning	24
F.	Maintaining and Troubleshooting the PAM	25
F.1	Maintenance	25
F.2	Troubleshooting	25
F.3	Service through 2B Technologies	25
G.	Labeled Instrument Photos	26
H.	Replacement Parts	28
I.	Service Log	28
APPENDIX 1:	Additional PAM Specifications	30
Overview		30
Overall Specifications and Dimensional Drawings		31
Sensor Specifications		32
Power and Battery		32
Printed Circuit Board.....		32
GPS Module.....		32
APPENDIX 2:	Operation of PAM within Mobile Enclosure (“CarTopper” Mode)	33
2.A	Overview.....	33
2.B	Instructions	34
2.C	Specifications and Dimensional Drawings	35
APPENDIX 3:	Operation of PAM with Stationary Enclosure	36
3.A	Instructions for Installing Power Cable for Inputting 12V DC to the PAM	36
3.B	Wiring if Inputting AC Power to the PAM Enclosure	39
3.C	Specifications and Dimensional Drawings	42
APPENDIX 4:	AQTreks Smartphone App	43

IDENTIFICATION RECORDS

Record the following information for future reference:

Unit serial number: _____

Warranty start date: _____
(date of receipt)

PRINTING HISTORY

This manual covers the Personal Air Monitor (PAM) used for measurement of carbon monoxide (CO), carbon dioxide (CO₂) and particulate matter (PM₁ and PM_{2.5}) in air. Also included are appendices describing the use of the PAMs within mobile cartop carriers (our CarTopper™) and stationary enclosures. New editions of this manual are complete revisions that reflect updates to the instrument itself, as well as clarifications, additions and other modifications of the text.

Revision B-1	May 2021
<i>Updated pictures to show new Plantower, USB-C connection, SD card block; added appendices for CarTopper and stationary PAM. Several additions and clarifications to the text.</i>	
Revision B-2	September 2021
<i>Updated pictures and steps in Appendix 3 to show more detail on installing the PAM within the outdoor enclosure.</i>	
Revision B-3	October 2021
<i>Added section in Appendix 3 to show wiring steps if using AC input.</i>	
Revision B-4	January 2022
<i>Correction to AC wiring shown in Appendix 3.</i>	
Revision C-1	February 2022
<i>Added info about data access via Data Portal on the 2B Tech website, Sections A. C.4 and D.</i>	
Revision C-2	March 2022
<i>Added dimensional drawings and specifications in Appendices 1, 2, and 3.</i>	
Revision D-1	April 2022
<i>Updated serial menu commands in Section C.3.1. Delete section C.1.7 on data viewing and download, as it has been replaced by the Data Portal (Section C.4). Omit step 1.g in Section D, as there is no longer an option to set time zones.</i>	
Revision E-1	January 2023
<i>Major update to reflect new version of the PAM, including new photos, procedures, and serial menu.</i>	
Revision E-2	March 2023
<i>Update to serial commands.</i>	
Revision E-3	July 2023
<i>Update to serial commands.</i>	
Revision E-4	August 2023
<i>Update to serial commands. Add item to Troubleshooting Section F.2 for firmware update capability.</i>	
Revision E-5	December 2023
<i>Updated hyperlinks. Describe new Data Portal in Section C.1. Describe new smartphone app, 2B Connect, in Section C.4 and move info about the AQTreks app to Appendix 4.</i>	
Revision E-6	December 2023
<i>Formatted Data Portal Section C.1 and added information (Sections C.1.3-C.1.5).</i>	

TRADEMARKS & PATENTS

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CONFIDENTIALITY

The information contained in this manual may be confidential and proprietary and is the property of 2B Technologies. Information disclosed herein shall not be used to manufacture, construct, or otherwise reproduce the goods disclosed herein. The information disclosed herein shall not be disclosed to others or made public in any manner without the expressed written consent of 2B Technologies.

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WARRANTY STATEMENT

2B Technologies warrants its products against defects in materials and workmanship. 2B Technologies will, at its option, repair or replace products that prove to be defective. The warranty set forth is exclusive and no other warranty, whether written or oral, is expressed or implied. 2B Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Warranty Period

The warranty period is one (1) year from date of receipt by the purchaser, but in no event more than thirteen (13) months from original invoice date from 2B Technologies.

Warranty Service

Warranty Service is provided to customers via web ticket, email, and phone support, Monday - Friday, from 9:00 a.m. to 5:00 p.m., Mountain Time USA. The preferred method of contacting us is through our web ticketing software at:

<https://2btech.io/support/>

By contacting 2B Tech this way, all technical staff will be alerted of your problem and will be able to respond. When you receive an email reply, please click on the Ticket link provided to continue to communicate with us directly over the internet. The web ticket approach to customer service allows us to better track your problem and be certain that you get a timely response. We at 2B Tech pride ourselves on the excellent customer service we provide.

You may also contact us by email at techsupport@2btech.io or by phone at +1(303) 273-0559. In either case, a web ticket will be created, and future communications with you will be through that ticket.

Initial support involves trouble-shooting and determination of parts to be shipped from 2B Technologies to the customer in order to return the product to operation within stated specifications. If such support is not efficient and effective, the product may be returned to 2B Technologies for repair or replacement. Prior to returning the product, a Repair Authorization Number (RA) must be obtained from the 2B Technologies Service Department. We will provide you with a simple Repair Authorization Form to fill out to return with the instrument.

Shipping

2B Technologies will pay freight charges for replacement or repaired products shipped to the customer site. Customers shall pay freight charges for all products returning to 2B Technologies.

Conditions

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance, adjustment, calibration or operation by the customer. Maintenance, adjustment, calibration or operation must be performed in accordance with instructions stated in this manual. Usage of maintenance materials purchased from suppliers other than 2B Technologies will void this warranty.

Limitation of Remedies and Liability

The remedies provided herein are the Customer's sole and exclusive remedies. In no event shall 2B Technologies be liable for direct, indirect, special, incidental or consequential damages (including loss of profits) whether based on contract, tort or any other legal theory. The Personal Air Monitor manual is believed to be accurate at the time of publication and no responsibility is taken for any errors that may be present. In no event shall 2B Technologies be liable for incidental or consequential damages in connection with or arising from the use of the Personal Air Monitor manual and its accompanying related materials. Warranty is valid only for the country designated on the 2B Technologies quote or invoice.

WARNINGS

ENGLISH

**WARNING:**

Any operation requiring access to the inside of the equipment, could result in injury. To avoid potentially dangerous shock, disconnect from power supply before opening the equipment.

**WARNING:**

This symbol,  on the instrument indicates that the user should refer to the manual for operating instructions.

WARNING:

If this instrument is used in a manner not specified by 2B Technologies, USA, the protection provided by the instrument may be impaired.

ESPAÑOL

**ATENCIÓN:**

Cualquier operación que requiera acceso al interior del equipo, puede causar una lesión. Para evitar peligros potenciales, desconectarlo de la alimentación a red antes de abrir el equipo.

**ATENCIÓN:**

Este símbolo,  en el instrumento indica que el usuario debería referirse al manual para instrucciones de funcionamiento.

ATENCIÓN:

Si este instrumento se usa de una forma no especificada por 2B Technologies, USA, puede desactivarse la protección suministrada por el instrumento.

FRANÇAIS

**ATTENTION:**

Chaque opération à l'intérieur de l'appareil, peut causer du préjudice. Afin d'éviter un choc qui pourrait être dangereux, déconnectez l'appareil du réseau avant de l'ouvrir.

**ATTENTION:**

Le symbole,  indique que l'utilisateur doit consulter le manuel d'instructions.

ATTENTION:

Si l'instrument n'est pas utilisé suivant les instructions de 2B Technologies, USA, les dispositions de sécurité de l'appareil ne sont plus valables.

DEUTSCH

**WARNHINWEIS:**

Vor dem Öffnen des Gerätes Netzstecker ziehen!

**WARNHINWEIS:**

Dieses,  auf dem Gerät weist darauf hin, daß der Anwender zuerst das entsprechende Kapitel in der Bedienungsanleitung lesen sollte.

WARNHINWEIS:

Wenn das Gerät nicht wie durch die Firma 2B Technologies, USA, vorgeschrieben und im Handbuch beschrieben betrieben wird, können die im Gerät eingebauten Schutzvorrichtungen beeinträchtigt werden.

ITALIANO

**ATTENZIONE:**

Qualsiasi intervento debba essere effettuato sullo strumento può essere potenzialmente pericoloso a causa della corrente elettrica. Il cavo di alimentazione deve essere staccato dallo strumento prima della sua apertura.

**ATTENZIONE:**

Il simbolo,  sullo strumento avverte l'utilizzatore di consultare il Manuale di Istruzioni alla sezione specifica.

ATTENZIONE:

Se questo strumento viene utilizzato in maniera non conforme alle specifiche di 2B Technologies, USA, le protezioni di cui esso è dotato potrebbero essere alterate.

DUTCH

**OPGELET:**

Iedere handling binnenin het toestel kan beschadiging veroorzaken. Om iedere mogelijk gevaarlijke shock te vermijden moet de aansluiting met het net verbroken worden, vóór het openen van het toestel.

**OPGELET:**

Het symbool,  geeft aan dat de gebruiker de instructies in de handleiding moet raadplegen.

OPGELET:

Indien het toestel niet gebruikt wordt volgens de richtlijnen van 2B Technologies, USA gelden de veiligheidsvoorzieningen niet meer.

CHINESE

**警告：**

任何需要接触设备内部的操作均可能造成人身伤害。为避免可能的触电危险，请在打开设备前切断电源。

**警告：**

这个符号  在仪器上表示用户应参考说明书上的操作指南。

警告：

如果仪器没有按照美国 2B 科技公司指定方式操作，仪器的保护性能会减弱。

JAPANESE

**警告：**

機器の内部で操作する時、怪我できます。危険な衝撃を回避するために、機器を開ける前に、電源を切断してください。

**警告：**

機器でこの記号  を見れば、マニュアルを読んでください。

警告：

この機器は 2B テクノロジー会社、USA の指定でなければ、機器の保護が損なえます。

UNPACKING THE SHIPPING BOX

Please read all the following information before attempting to install the Personal Air Monitor. For assistance, please call 2B Technologies at (303)273-0559.

NOTE:

Save the shipping carton and packing materials that came with the Personal Air Monitor. If the Personal Air Monitor must be returned to the factory, pack it in the original carton. Any repairs due to damage incurred during shipping will be charged.

Shipping Box Contents

Open the shipping box and verify that it contains all of the items on the shipping list. If anything is missing or obviously damaged, contact 2B Technologies immediately by email at techsupport@2btech.io or by phone at +1(303) 273-0559.

A. Overview: Personal Air Monitor (PAM) Sensor Measurements

The PAM uses sensors to measure air pollutants and instrument temperature, pressure, and relative humidity. The PAM was initially developed for mobile monitoring of CO, CO₂, and particulate matter (PM) during walking “Treks” designed by students, educators, and the public in our AQTreks program.

Trace gas measurements of the PAM include CO₂, Particulate Matter (PM₁, PM_{2.5}, and PM₁₀), and the choice of either of these two of these additional sensors: CO, and total VOCs. Other sensors measure temperature, relative humidity, and pressure conditions inside the PAM enclosure. More detail about the PAM and its sensors can be found in Appendix 1. Appendices 2 and 3 describe options for its use in mobile and stationary measurements.

Note that although the PAM data stream contains data for PM₁, PM_{2.5}, and PM₁₀, the PM₁₀ data should be neglected because the PAM sample inlet is not adequate for the proper sampling of PM₁₀.

Several methods of viewing/accessing the data are available in the PAM:

- Data from the PAM can be viewed in real time on your **cell phone** using our free app, 2B Connect.
- Via WiFi, data are transmitted to a **Data Portal on the 2B Technologies website**, where they can be accessed later for analysis. If the cellular option has been purchased for your PAM, the data are also transmitted to the Data Portal via cellular when a cell signal is present. The portal is on a tab at the top menu bar of <https://2btech.io>.
- Data are stored on a **micro-SD data card** inserted into the PAM and can be viewed on your computer.
- Data can also be viewed on **your computer** in real time by connecting the **PAM’s serial port** to your computer’s USB port and using a free downloadable data acquisition program such as [TeraTerm](#).

Labeled photos of the PAM are given on the next two pages. The rest of this manual gives instructions for starting up and acquiring data with your Personal Air Monitor.

Standard on the PAM	Options and Customer Choices
CO ₂ sensor	Sensor 1 (CO or TVOCs)
PM sensor (particulate matter)	Sensor 2 (CO)
Temp/RH sensor	Cellular data upload capability
Pressure sensor	
GPS	
WiFi data upload capability	
Micro-SD data card	
Serial connectivity to computer	
Battery or external power operation	

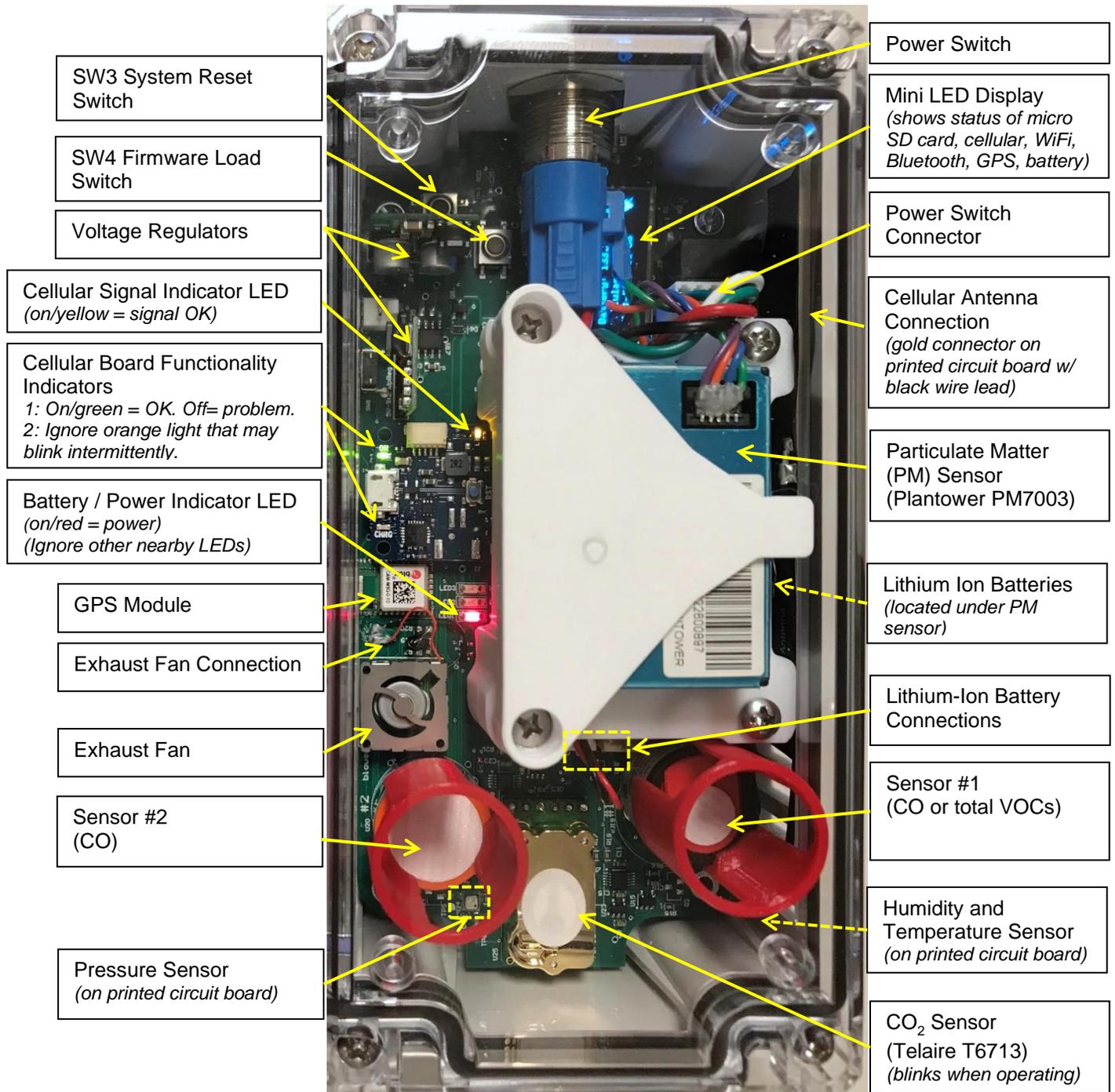
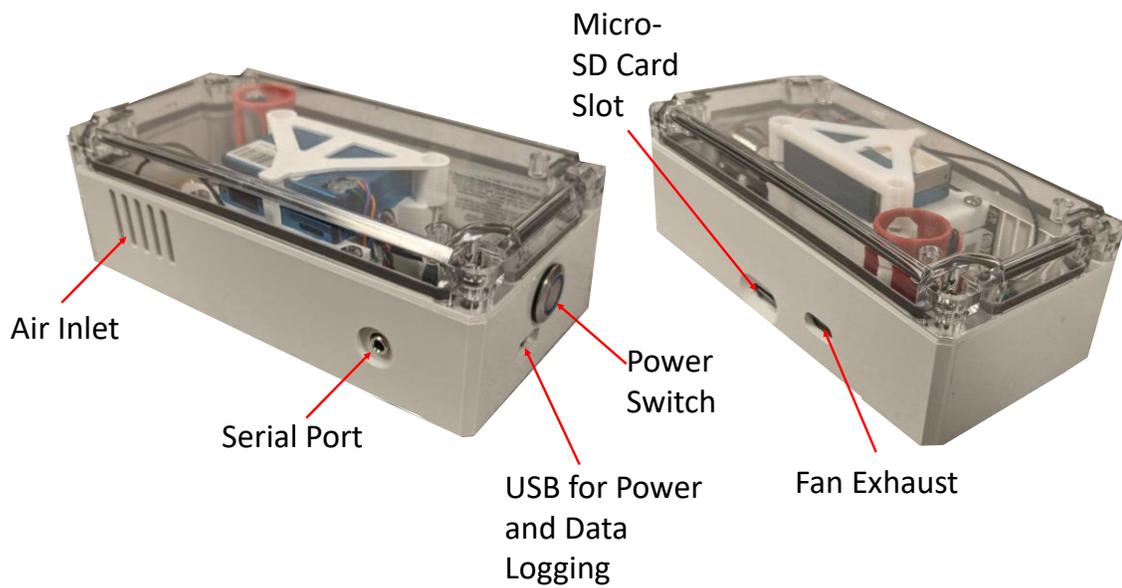


Figure A.1. PAM Top View (above) and Side Views (next page).



The PAM's charger, USB-C cable, and micro-SD card reader are provided as accessories.

Safety Notice

The PAM contains lithium-ion batteries that have a maximum operating temperature of 45 °C.

B. Startup of the PAM

B.1 Initial Check of the PAM

After unpacking, please check to make sure the PAM is working. Do not remove the micro-SD data card that is installed on your PAM.

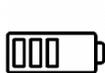
1. Use the supplied USB-C cable and charger to connect to power. Orientation of the USB-C in the PAM does not matter. Do not press the PAM's power button yet.
2. Look for the red LED on the PAM printed circuit board to turn solid red when plugged into external power. This light must be on for the PAM to be functional. If the red LED does not come on, try to plug and unplug the charger and the USB connection (or try a different cable) until you see the solid red LED shown in the yellow circle below. It is labeled **A** in the photo on the next page.



One LED will be on solid red when power is supplied to the PAM.

The two nearby LEDs may flicker occasionally, but they should be ignored.

3. The PAM's batteries are charging when external power is supplied and the red light is on as above. (The red light will stay on even when the batteries are fully charged.) With a full charge, the battery life of the PAM is approximately 6-8 hours, depending on cell upload settings. To maintain fully charged batteries, keep the PAM plugged into external power when not in use.
4. Power on the PAM using button **B** as shown in the next photo. Press the power button **ONLY ONCE** and wait a few seconds for the power button to light up and the PAM to turn on.
5. You should hear the faint sound of the fan **C** running.
6. The Mini LED Display **D** will initialize and then begin to rotate through the trace gas measurements being received. It also indicates the time/date and the status of the batteries, WiFi, cellular (if this option is purchased), GPS, Bluetooth, and the SD card. Confirm that the time/date are correct, and that the capabilities you expect to see are present and operating.



Battery



WiFi



Cellular



GPS



Bluetooth



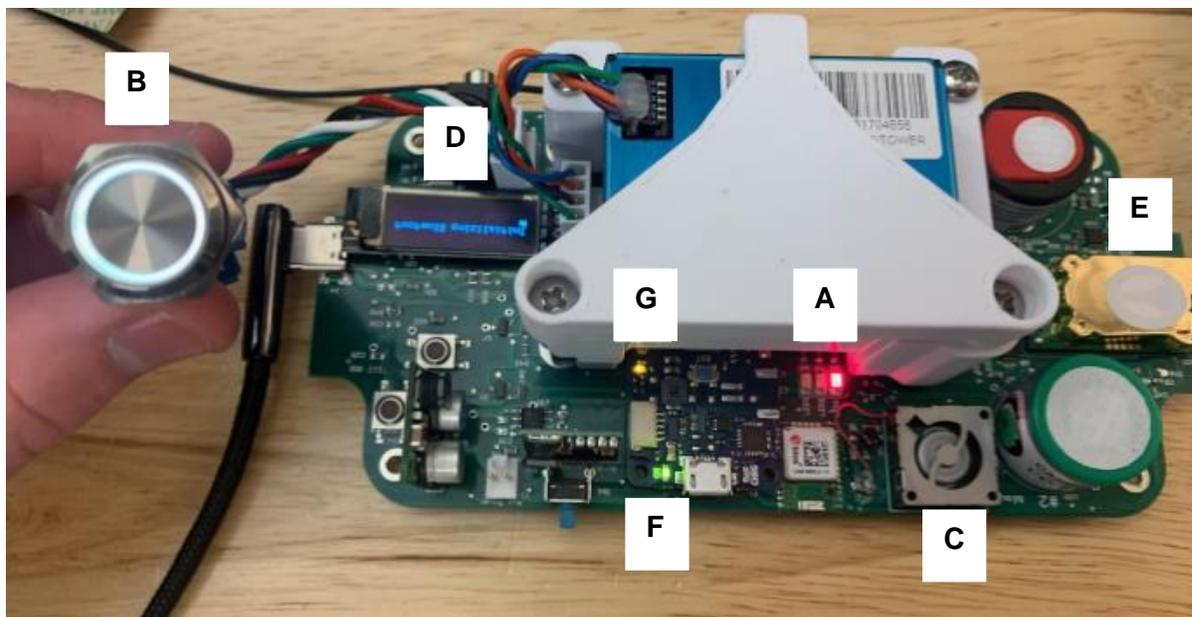
SD card

A horizontal line through a symbol indicates it is not operating or not present.

-
7. The CO₂ sensor **E** (on the end opposite from the power switch) intermittently blinks when it is making measurements.
 8. If the PAM has been purchased with the option for cellular communication, there is a separate small circuit board for cellular. It has 3 indicator lights:
 - A green light indicator light **F** will be on, indicating the board is functional.
 - Another indicator light **G** will go on (yellow) when a cell signal is established.
 - You may also see another indicator light that blinks orange, near the green light. Ignore this orange indicator light.
- If your PAM fails to receive a cell signal, try moving to another area or restarting the PAM. If no signal, use the serial menu (Section C.3) to first confirm that cellular is enabled, and then to run the further debugging capabilities if needed.
9. If you wish to upload data using WiFi, see the instructions in Section D for enabling WiFi and then entering your network's credentials.
 10. Time is in UTC. See Section D.1 to adjust the clock to your time zone if desired.
 11. Be sure the PAM's inlet and exhaust are not obstructed. Note that the CO and NO₂ measurements are not valid until the PAM has warmed up for 20-30 minutes.

When the cellular and/or WiFi connection is established, data are being transmitted to Data Portal of the 2B Tech website: <https://2btech.io>. Data are also stored on the PAM's internal micro-SD card (installed in the PAM when shipped from the factory).

Successful completion of the above steps indicates that your PAM is working properly. Proceed to the next section.



For greater clarity, the photo shows the PAM without its enclosure and with the power button detached.

B.2 The PAM's micro-SD Data Card

The PAM provides portable data storage via a micro-SD data card. This 32 GB card is installed when the PAM is shipped from the factory. The PAM's mini-LED display should indicate its presence (refer to Section B.1 step 6).



A new data file is created on the card each day at midnight (previously written files are maintained). The data on the card can be accessed later for analysis (see Section C).

Please leave the factory-installed card in the PAM as you first start using the PAM and do not try to remove it. If no micro-SD card is inserted, the PAM will still function, but it will output data at a lower frequency. Therefore, we recommend that the PAM always be operated with the data card inserted.

Please read instructions in Section C before attempting to remove the micro-SD card.

B.3 Power Up and Begin Test Measurements

You are ready to begin test measurements with the Personal Air Monitor.

1. Without powering on, plug in the PAM to its charger and plug the charger into a power source. Alternatively, plug the PAM's USB cable into a computer to provide power. Verify that the red LED comes on near the center of the PAM.



2. Locate the power switch for the PAM. Power on the PAM by pressing the button **ONLY ONCE**. After a short delay of a few seconds, the button will light up and the PAM will turn on. If the cellular option is present and enabled, verify its green and yellow LEDs are on as described in step 8 of Section B.1.



3. Be sure the PAM's inlet and exhaust (on the long sides of the PAM) are not obstructed.
4. The initial readings of CO and NO₂ are unreliable until the PAM has warmed up (~20-30 minutes).
5. The PAM outputs data every ~3-4 seconds (if an NO₂ sensor is present in the PAM, the output is every 12-15 seconds to give better performance).
6. See the Section C of this manual for information on data viewing and downloading.
7. Follow instructions in Section D to be sure your PAM is initialized the way you desire before beginning your actual data acquisition.

The PAM is designed to be used for mobile measurements, whether hand-held or mounted on a moving platform such as a vehicle (Appendix 2). It can of course also be used for stationary measurements at a fixed site (Appendix 3).

C. Data Viewing and Downloading with the PAM

Note that we have redesigned the PAM in 2023. Along with this major redesign, we are updating to a new Data Portal, a new serial menu, and a new smartphone app.

This section describes the various options available for viewing and downloading the data you acquire with your PAM. See Section D for additional settings to adjust if using WiFi and/or cellular to upload data, or if using the micro-SD card data. Note:

Complete Section B before proceeding.
If you wish to store data on the micro-SD card, make sure you have a card inserted in the PAM (see Section B.2).

If no micro-SD card is inserted, the PAM will still function, but it will output data at a lower frequency. Therefore, we recommend that the PAM always be operated with the data card inserted. Data are output every 3-4 seconds (if an NO₂ sensor is present, the output is every 12-15 seconds to give better performance).

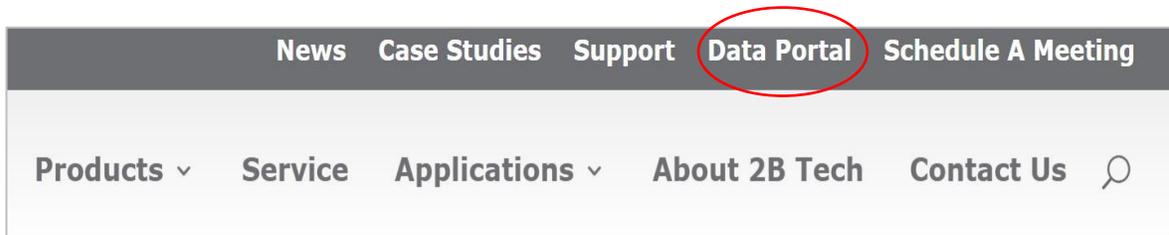
C.1 Web Data Access on the 2B Tech Portal (via WiFi and/or cellular)

Data from the PAM are uploaded to the web when either WiFi or cellular are available. Section D describes how to establish/confirm the WiFi and/or cellular connection.

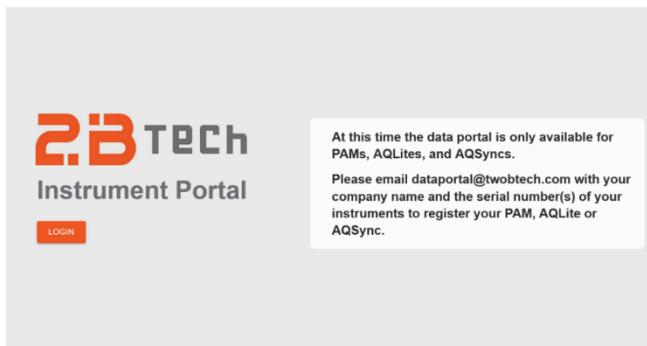
C.1.1 Login to the 2B Tech Data Portal

Web access is via a Data Portal on the 2B Tech website. The Data Portal is used with three 2B Tech instruments: the PAM, the AQLite-Standard, and the AQSync. The PAM acquires raw data every few seconds. The portal gives options for selecting the averaging time for the data and creating a csv file. **Contact dataportal@2btech.io to set up an account for the Data Portal.** Then:

- a) Access the website <https://2btech.io>. Choose “Data Portal” from the top menu bar.

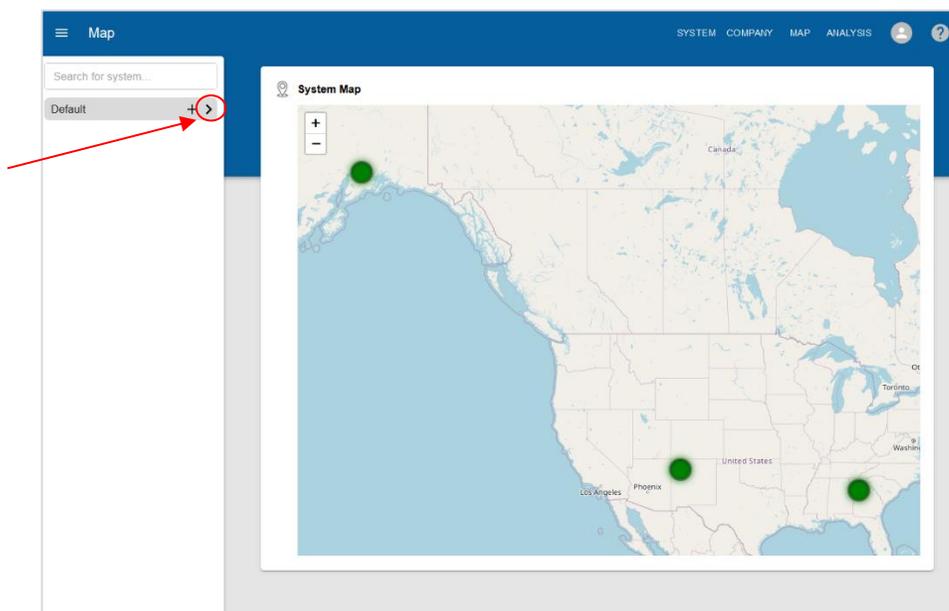


b) Click on the orange “Login” button and use your login credentials to login.



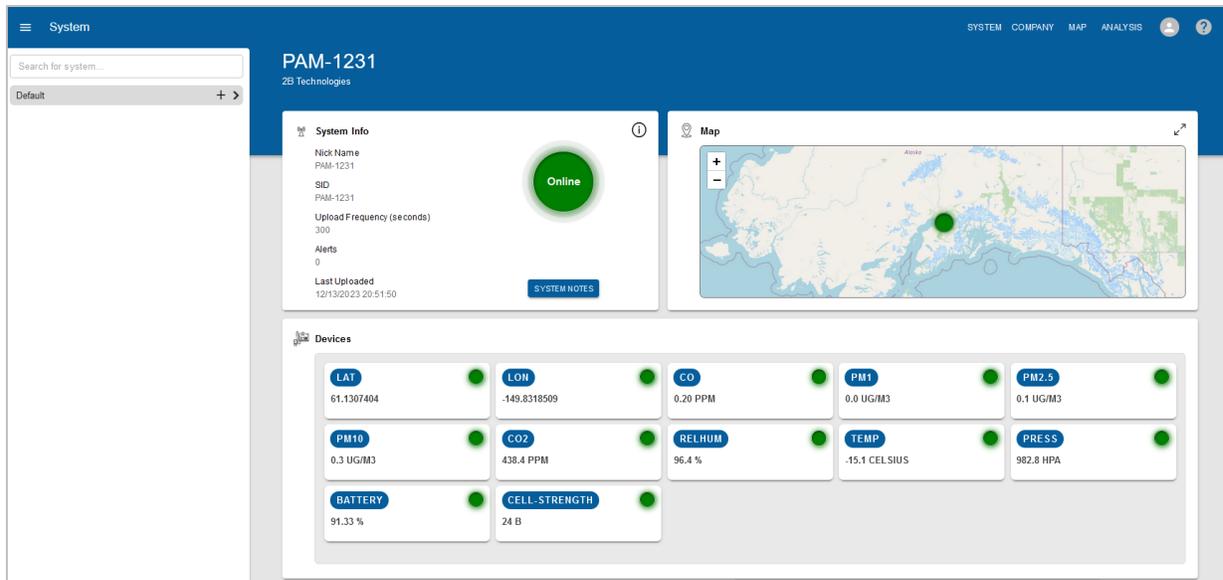
C.1.2 Viewing the Data

A few minutes after logging in, you will see the dashboard. On the left side is a default folder containing a list of all your instruments, identified by their serial numbers (use the pulldown arrow to view them). To the right they are displayed on a map.

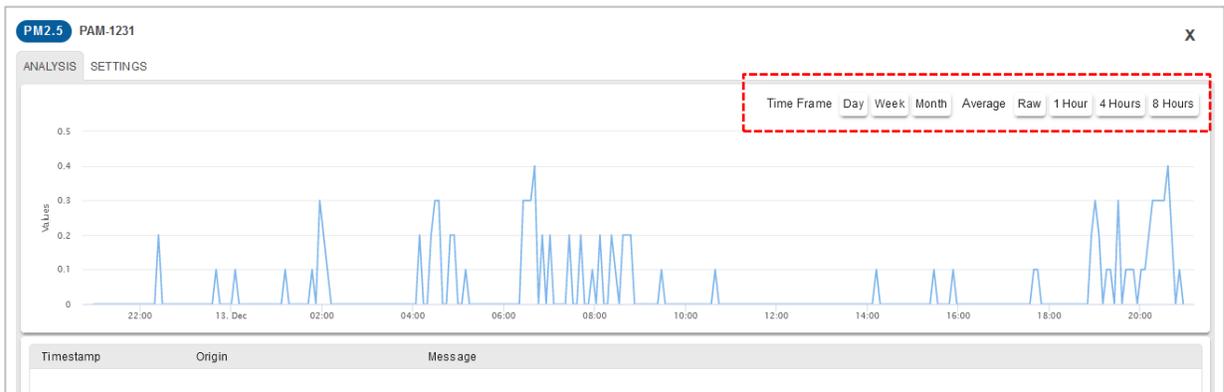


Display your instruments using the “>” pulldown on the Default tab. If the instrument is online, it is shown as a green circle in the list at the left and in the System Info box next to the map.

Click on an instrument name/serial number to see the instrument (see next page for screenshot). The various measurements of that instrument are shown as a grid of boxes in the Devices section, with their status shown in a circle that is either green (functioning) or yellow. Yellow indicates there is an issue with that PAM measurement (click on the circle to get information). The PAM serial number is located on the back of the instrument case.

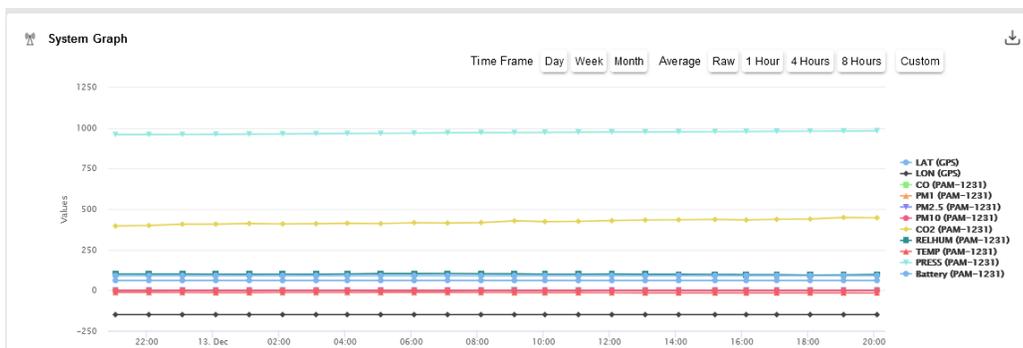


Click on the box for any of the measurements with “green” status to see a graph of its data, as in this example for PM_{2.5}:

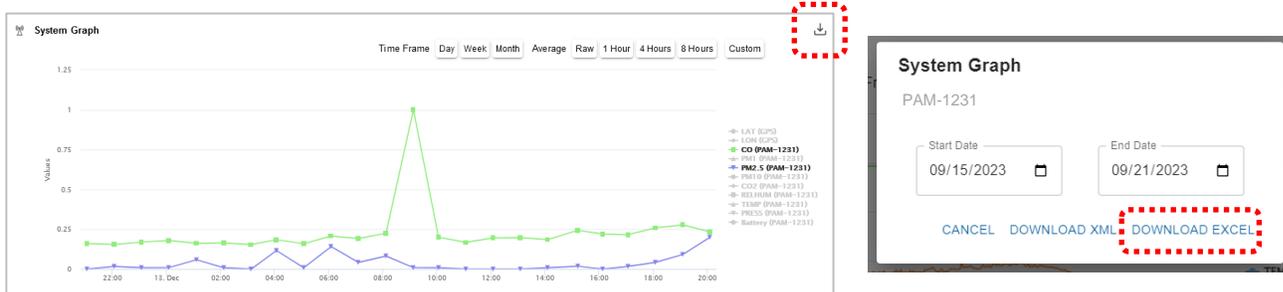


Hover over any point with the cursor to see its data value. The time frame for the data, as well as the averaging time, can be specified from the menu along the top of the graph. Note that the “Settings” tab is currently under development. It will display instrument parameters in the future.

A graph of all the measured parameters appears at the bottom of the main screen. Use the menu buttons to choose the Time Frame and Averaging period or enter custom values for those quantities.



Click on any of the parameters to display only its data (autoscaled) on the System Graph. Multiple measurements can be displayed by clicking on them as shown below. Click again on the displayed item in the legend to return to displaying all measured parameters.



Click the icon in the upper right corner to download the displayed data. You can choose the date range for the file that will be created. The file is named “PAM-xxxx.csv,” where xxxx is the serial number of your PAM.

The file column headings in the csv data file are largely self-explanatory. The headings contain the serial number of the PAM module used in measuring the parameters.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Averaged Start Date (UTC)	Averaged End Date (UTC)	GPS:LAT (LAT)	GPS:LON (LON)	PAM-1231:CO (PPM)	PAM-1231:PM 1 (UG/M3)	PAM-1231:PM2.5 (UG/M3)	PAM-1231:PM10 (UG/M3)	PAM-1231:CO2 (PPM)	PAM-1231:RELHUM (PERCENTAGE)	PAM-1231:TEMP (CELSIUS)	PAM-1231:PRESS (HPA)	PAM-1231:Battery (PERCENTAGE)	PAM-1231:Cell-Strength (BYTE)
12/13/2023 4:13	12/13/2023 4:13	61.1304989	-149.8316058	0.15	0	0	0	394.7	101.6	-11.8	959.8	91.33	24
12/13/2023 4:18	12/13/2023 4:18	61.1305031	-149.8315753	0.16	0	0	0	395.6	101	-11.9	959.8	91.33	23
12/13/2023 4:23	12/13/2023 4:23	61.1304703	-149.8315194	0.15	0	0	0.2	396.7	101.1	-11.9	959.8	91.33	24
12/13/2023 4:28	12/13/2023 4:28	61.1306444	-149.8317119	0.14	0	0	0	393.7	101.4	-11.9	959.8	91.33	23
12/13/2023 4:33	12/13/2023 4:33	61.1307444	-149.8318902	0.16	0	0	0.2	395	101.3	-11.9	959.7	91.33	23
12/13/2023 4:38	12/13/2023 4:38	61.1307327	-149.8318185	0.15	0	0	0	398.1	101.7	-11.9	959.6	91.33	24
12/13/2023 4:43	12/13/2023 4:43	61.1307651	-149.8316026	0.14	0	0	0	396.5	101.2	-11.9	959.5	91.33	23

The “Download XML” choice is used to access geolocated data gathered during treks with your PAM.

C.1.3 Organizing Your Instruments

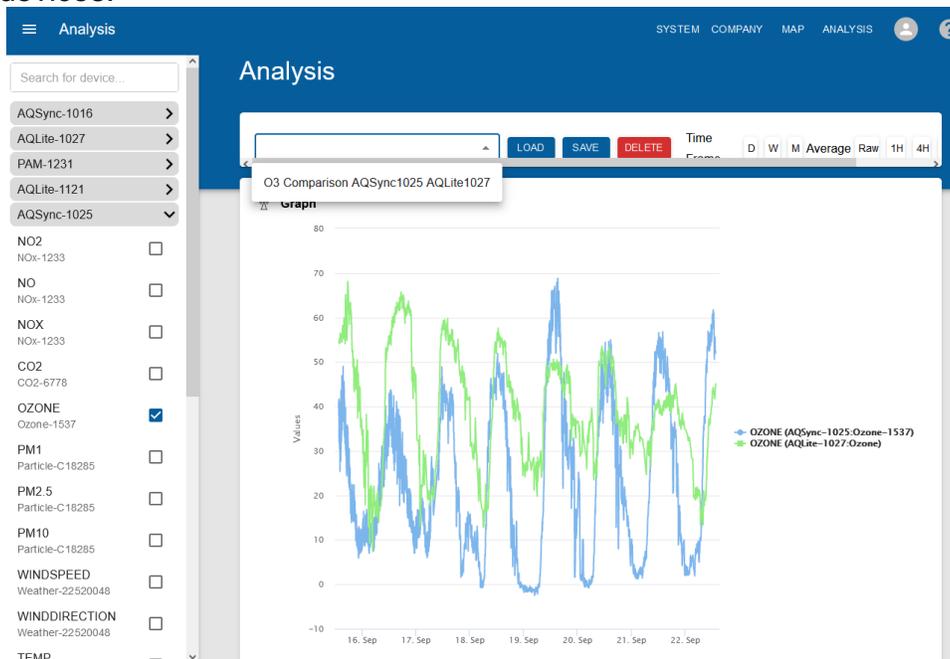
All of your instruments are shown in the “Default” folder upon first login. Users with Admin status can create project folders (done in the “Company” tab). Click on the “+” sign of a project folder to move an instrument from the Default folder into that project folder.

C.1.4 Viewing/Comparing Data from Different Instruments

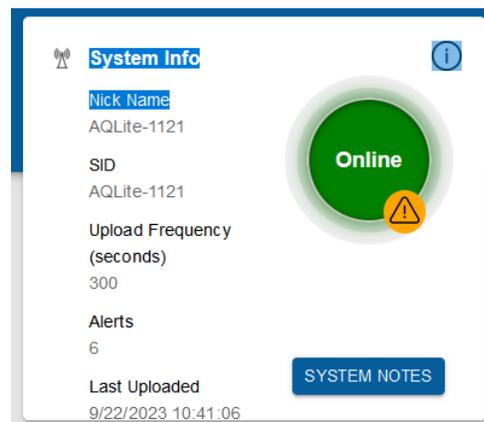
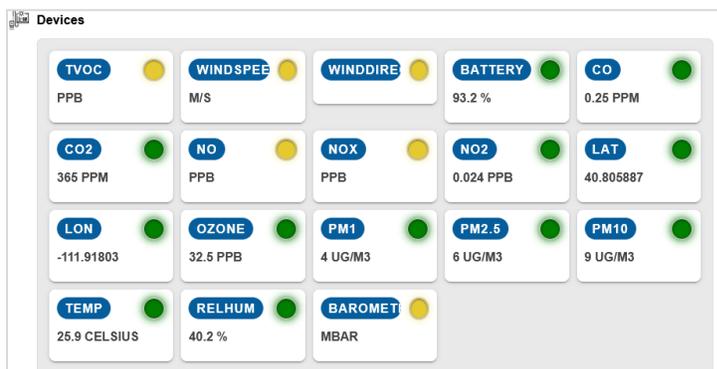
The “Analysis” tab in the upper right corner of the main screen enables you to compare data across multiple instruments.



Use the Device pulldown menus to select the items you wish to compare on the graph. Adjust the time frame and averaging as desired. If you want to frequently check the same comparison, you can “Save” it and name it. To compare it again in the future, click “Load” and select its name. Delete any named comparisons that you no longer want. The example below shows a comparison of ozone data from 2 different devices.



C.1.5 Troubleshooting



If one of your measurements has a problem, it will have a yellow circle next to it, and an orange warning triangle will appear on the system’s green circle as shown above on the right. Click on the measurement box to get information about the problem. (The examples above are for the AQSync and AQLite, but the same principles apply to the PAM.)

Click on “System Notes” to see an overview of problems with your instrument.

C.2 Accessing the PAM's Micro-SD (μ SD) Card Data

A 32 GB micro-SD card is installed when your PAM is shipped from the factory. Data acquired by the PAM is stored on this card and can be accessed via a card reader of computer for transferring and analysis. A few points about the data card:

- If no data card is inserted, the PAM will still function, but it will output data at a lower frequency. Therefore, we recommend that the PAM always be operated with a micro-SD card inserted.
- A new file is created on the card every day at midnight.
- The card is located on the side of the PAM next to the exhaust fan. A white plastic barrier is in place to prevent the micro-SD card from falling into the enclosure.

The micro-SD card slot is shown below. Note the white barrier below the slot, which prevents the SD card from being dropped into the cavity below.



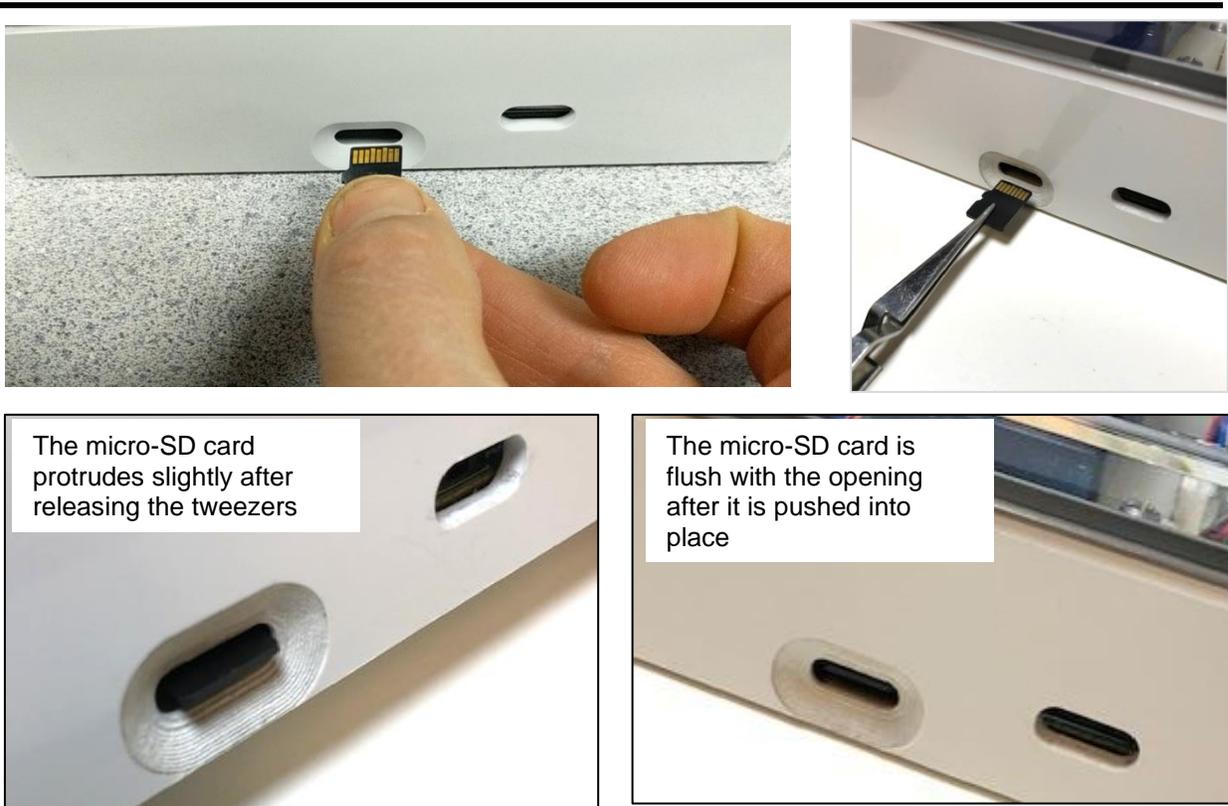
- The card is very small and can be difficult to eject and insert so take great care when accessing the card. See instructions below
- **Note that it is best practice to have the PAM turned off when inserting or removing the card.**

To remove the card:

1. Turn the PAM off.
2. Use a small flat head screwdriver to gently press in the card and release, so that it ejects. *It ejects using a spring-loaded mechanism, so be prepared to block its trajectory!*

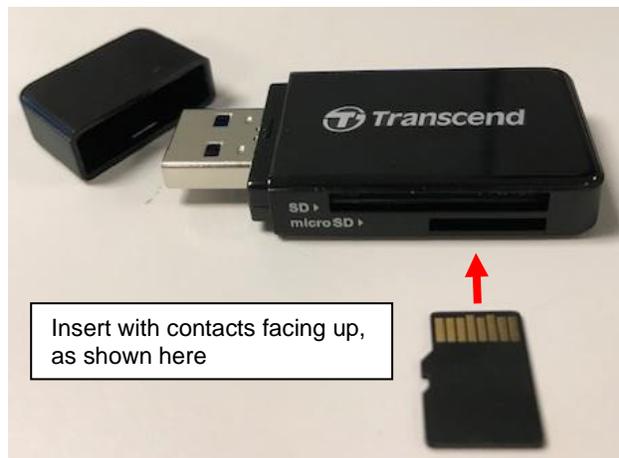
To Insert the card:

- Turn the PAM off.
- It is easiest to use tweezers to hold the SD card, but it can also be inserted by hand. Be sure not to touch the contacts with the tweezers. Partially insert the card carefully into the receiving tray, with the **card's contacts facing UP** as shown in the photo.
- With the card partly into the tray, release the tweezers. The card will protrude slightly.
- Use your finger to push the micro-SD card so that it is flush with the edge of the PAM. You will hear/feel a slight click as it engages. If it is correctly installed, the card will be flush with the opening and will not protrude from the PAM.



Data files on the card

- Data files are located on the μ SD card and labeled as such “XXXX_YYYY-MM-DD.txt” where “XXXX” is the serial number of your PAM, and YYYY-MM-DD is the date. For example, 1175_2022-11-22 would indicate PAM serial number 1175 on November 22, 2022.
- The values printed out in the data string are shown after step 12 below, and further described in Section C.3.2.
- To view the data on the card without ejecting it, connect your computer to the PAM’s serial port.
- To transfer the data to your computer, turn off the PAM. Gently press in the micro-SD card to eject it. (*Caution, spring-loaded!*)
- Insert the card into the card reader provided with the PAM (contacts facing up).
- Insert the card reader into the USB of your computer and open the data file of interest. The output will show the data for the specific sensors on your PAM. It will look similar to the



output shown below for PAM SN 1175.



```
*1175_2022-11-22.txt - Notepad
File Edit Format View Help
File Start timestamp:
2022-11-22,18:48:27
DeviceId,NO2(PPB),PM1(UGM3),PM2.5(UGM3),PM10(UGM3),VOC(PPB),CO2(PPM),RELHUM(%),TEMP(C),PRESS(HPA),LAT(LAT),LON(LON),Battery(%),Cellular(BYTES),Date,Time
1175,0.04,0,0,0,320.63,N/A,17.8,17.0,843.2,N/A,N/A,N/A,10000,2022-11-22,18:50:29
1175,-0.00,0,0,0,323.14,97,17.3,17.0,843.2,N/A,N/A,29.54,10000,2022-11-22,18:50:32
1175,0.01,0,0,0,320.05,428,17.1,17.1,843.2,N/A,N/A,29.54,10000,2022-11-22,18:50:35
1175,-0.01,0,1,1,316.60,428,16.9,17.1,843.2,N/A,N/A,29.54,10000,2022-11-22,18:50:38
1175,-0.01,0,1,1,316.82,622,16.8,17.1,843.3,N/A,N/A,29.54,10000,2022-11-22,18:50:41
1175,0.03,0,0,0,318.40,622,17.1,17.1,843.2,N/A,N/A,29.54,10000,2022-11-22,18:50:44
1175,0.03,0,1,1,314.52,690,17.7,17.1,843.3,N/A,N/A,29.54,10000,2022-11-22,18:50:47
```

C.3 USB to Computer or Data Logger

Data may be acquired while the PAM is connected to a computer or data logger. First, the appropriate driver and a terminal emulator must be installed (free downloads):

- Install the appropriate CP210x driver for your Windows or Mac computer from the web: <https://www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers?tab=downloads>
- Install a terminal emulator such as [TeraTerm](#). For Windows, use a serial terminal emulator to view the data in real time. For Linux, use Minicom or similar. If using a raspberrypi, use minicom or similar. Iterm2 should work for iOS.
 - a) With the PAM off, use the PAM's USB cable and any necessary USB adapters to plug the PAM into the USB of your computer or data logger.
 - b) Turn the PAM on.
 - c) Start up your terminal emulator. (Instructions below are stated for TeraTerm.)
 - d) TeraTerm will likely identify the correct COM port and begin displaying data. A new data line will appear approximately every 3-4 seconds (12-15 seconds if an NO₂ sensor is present on the PAM).
 - e) If TeraTerm does not begin displaying data, enter the Setup / Serial Port menu of TeraTerm and select a COM port from the list available (there may be more than one). You can find the correct COM port number in the Device Manager of your Windows machine, or by trial and error.
 - f) Be sure the correct baud rate is specified (115200).
 - g) Put the computer's cursor in the active TeraTerm window and click the mouse button to ensure it is the active window. Type "m" on the computer keyboard to enter the serial menu. Data acquisition continues while the menu is accessed.
 - h) Press '?' to view the menu items. Here you can change calibration factors, carry out debugging diagnostics, enable and disable cellular, and perform various other commands.
 - i) Type j to view the data string labels (output header string).
 - j) Your PAM will come with calibration factors applied for certain species.

The next section shows the structure of the serial menu and a listing of the serial commands.

C.3.1 Serial Commands

Main Menu

The serial structure is nested, with a Main Menu and Submenus. The Submenus are entered using the commands “a” and “b” shown in **red** below. Commands are for firmware 2.0.0 and above.

Command: Description

- a: Go to device list to access settings, enable/disable (*May have devices not in your PAM*)
- b: Go to list of debug options
- c: Enable status bytes for all devices (*Will change serial line to include these.*) [*Ignore; leave disabled unless working with 2B Tech on troubleshooting.*]
- d: Enable / Disable cellular [*See Section D.3*]
- e: Adjust frequency for uploading primary data (*in seconds*) [*See Section D.2*]
- f: Adjust frequency for uploading diagnostic data (*in seconds*)
- g: Enable / Disable WiFi [*See Section D.4*]
- h: Change WiFi credentials (*choose network and set password*) [*See Section D.4*]
- i: Enable / Disable CarTopper power mode. *If enabled, absence of external power will stop cellular.*
- j: Enter time zone (*adjust for shifts in local time such as daylight savings time*) [*See Section D.1*]
- k: Output header string
- l: Enable / disable SD card [*Disable/enable if removing/reinserting SD card with power on*]
- n: Calibrate CO2 sensor. *After choosing this option, take outside. Calibration will start in 1 minute.*
- o: Rotate OLED display
- p: List files on SD card and choose which to print in serial
- q: List files on SD card and choose which file to delete
- r: Switch Bluetooth mode [*“Beacon” or “Direct Connect”*]
- s: Set the date and time using GPS (*will not work without an active gps signal*)
- t: Set the date and time manually (*must enter in UTC*)
- u Restart ESP (have new settings be enabled) [*this is an internal power restart*]
- v: Set solar options for device [*new for firmware versions 2.0.0 and above*]
- ?: Output this menu
- x: Exits this menu

Submenu “a”: Device Settings

This is the list of all available devices (not all of these may be in your device)

Command: Description

- a: Socket 1
- b: Socket 2
- c: CO2
- d: Plantower-PM
- e: Sensirion-PM (This will automatically turn off Plantower-PM)
- f: TVOCs
- g: HIH (temp, relative humidity)
- h: BME (pressure)
- i: Methane
- ?: Output this menu
- x: Exits this menu

Choosing any of these brings up another submenu similar to this:
a: Disable (will not see this in effect until restart)
b: Change the slope
c: Change the zero
x: Exits this menu

Note that the population of Socket 1 and Socket 2 was customized when your PAM was ordered.

- *Socket 1 and Socket 2 could each contain a sensor for CO, SO₂, or NO₂.*
- *Socket 1 will be empty if a sensor for TVOCs was ordered, because the TVOCs sensor is placed in the space of Socket 1, but with different plug-in points.*

Submenu “b”: Debugging Operations

These choices will print out messages pertaining to specific parts of the PAM. For example, choosing “CO2 debug” will print out information about the CO2 sensor after restarting the PAM.

Note that not all of these choices pertain to the standalone PAM (for example, AQSync debug and ozone debug).

Also, commands are meaningful only for the sensors and features present on your PAM.

Command: Description

a: cellular debug
b: RTC debug
c: Socket 1/2 debug
d: CO2 debug
e: PM debug
f: TVOCs debug
g: HTH (temp, relative humidity) debug
h: BME (pressure) debug
i: Methane debug
j: AQSync debug
k: Ozone debug
l: Battery debug
m: Bluetooth debug
n: WiFi debug
o: SD card debug
p: GPS debug
?: Output this menu
x: Exits this menu

C.3.2 Serial Data String

Type “k” when in the serial menu to view the serial header that gives the data string labels. The output quantities are specific to your PAM, customized to show the sensors chosen when the PAM was ordered.

The header and data lines in the file for the PAM will look similar to the example below:

DeviceId,NO2(PPB),PM1(UGM3),PM2.5(UGM3),PM10(UGM3),TVOC(PPB),CO2(PPM),RELHUM(%),TEMP(C),PRESS(HPA),LAT(LAT),LON(LON),Battery(%),Cellular(BYTES),Date,Time

1175,82.4,5.2,42.1,83,560,499,30.5,16.9,833.8,40.021735,-105.217205,94.50,11017,2023-1-12,15:31:23

In this example:

Device ID (serial #)	1175 <i>(labeled on the back of your PAM)</i>
NO ₂ (ppb)	82.4
PM ₁ (µg/m ³)	5.2
PM _{2.5} (µg/m ³)	42.1
PM ₁₀ (µg/m ³)	<i>[ignore number, data currently not valid in the PAM]</i>
TVOCs (ppb)	560
CO ₂ (ppm)	499
Relative Humidity (%)	30.5 <i>(reflective of the PAM enclosure, not necessarily ambient)</i>
Temperature (°C)	16.9 <i>(reflective of the PAM enclosure, not necessarily ambient)</i>
Pressure (HPa)	833.8 <i>(likely close to ambient)</i>
Latitude	40.021735 degrees north <i>(will display “N/A” when there is no GPS signal)</i>
Longitude	-105.217205 degrees east <i>(will display “N/A” when there is no GPS signal)</i>
Battery status (%)	94.5
Cellular (bytes)	11017 <i>[ignore number; for 2B Tech diagnostics only]</i>
Date	January 12, 2023 <i>(YYYY-MM-DD format)</i>
Time	3:31:23 pm <i>(time, in military time format)</i>

Anything that is not working is logged as “N/A”.

C.4 Real-Time Data Viewing with Smartphone Application

2B Technologies has developed two smartphone apps for use with PAMs and other instruments of 2B Tech. The original app, “AQTreks”, was developed for our first-generation PAM. For our second-generation PAM released in 2023, we have developed a new app, “2B Connect”. Both can be downloaded for free using your smartphone. Though either app can be used for all PAMs, to achieve the highest functionality we recommend using the new 2B Connect app.

C.4.1 Previous App: “AQTreks”

We developed the “AQTreks” smartphone app for use with our first version of the PAM. It can also be used with the new generation of the PAM (in “Beacon” mode for Bluetooth). This app will display battery status, CO₂, CO, PM₁, PM_{2.5}, PM₁₀, T, RH, and P. Please note:

- The app will not display data for the TVOCs, SO₂, or NO₂ sensors that are available in some PAMs.
- The app cannot upload data.

The app is useful as a real-time check on your measurement conditions and the basic functionality of the PAM, and for storing data locally on your phone.

If you wish to continue using this application, please see Appendix 4 for more information. However as noted, we recommend using the new app “2B Connect” for highest functionality, described below.

C.4.2 New App: “2B Connect”

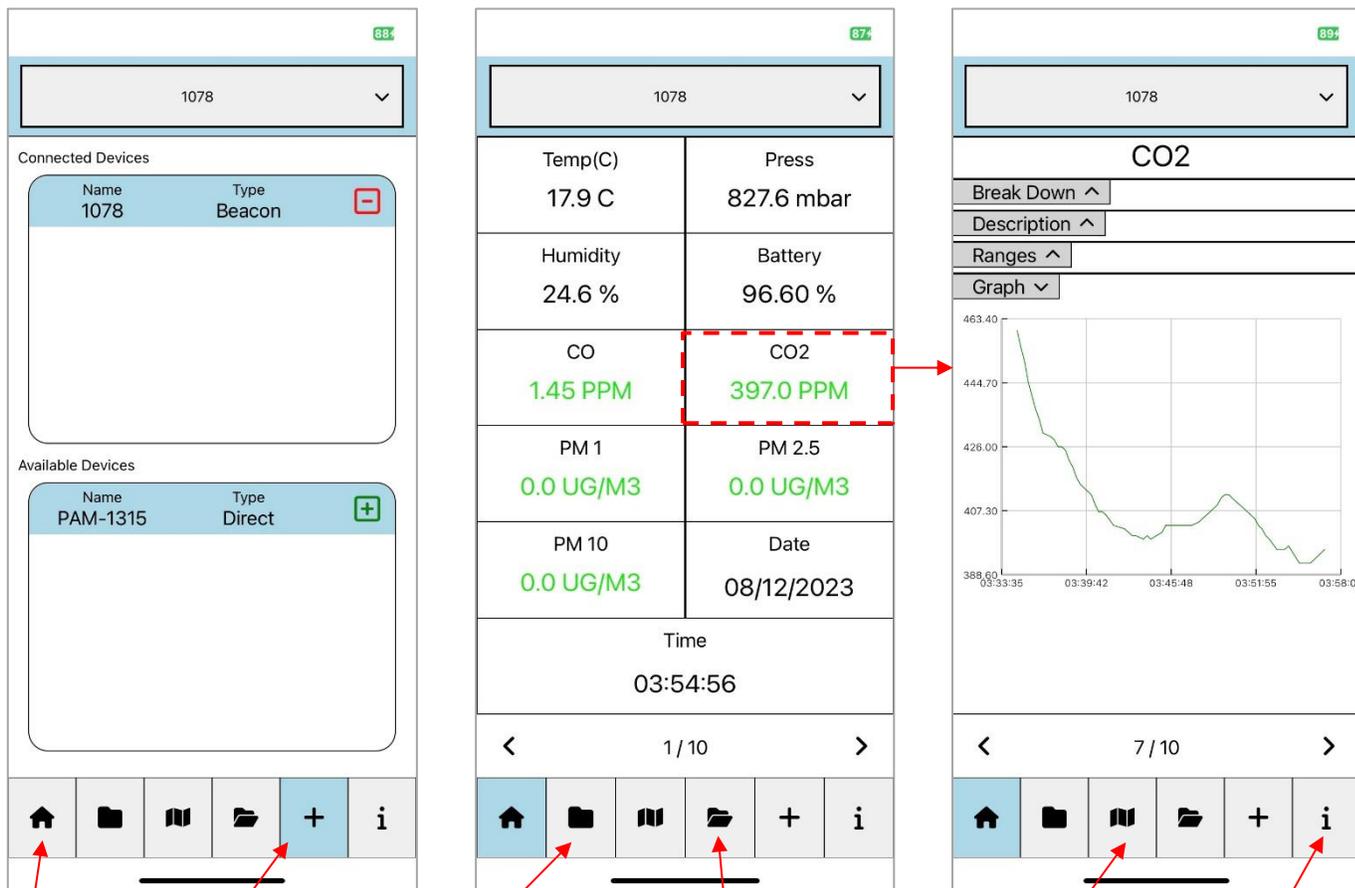
The free “2B Connect” app for Android or iOS is available by searching for “2B Connect” in the app stores. Open the app while the PAM is running and choose the appropriate PAM identification. Verify that the PAM is operational and to view the data. When using the app, you must enable Bluetooth. Detailed instructions are below.



1. Download the 2B Connect Smartphone application from the App Store (iOS devices) or Google Play (Android devices).
2. Install the app. You must accept all permissions for the app to work correctly.
3. Make sure Bluetooth is on.
4. Open the 2B Connect app.
5. View the short tutorial to acquaint yourself with the features of the app.
6. A brief overview of the app follows in the next steps. Please see the tutorial for more details not covered in this overview.



7. Power on the PAM by pushing the silver button on the end of the instrument.
8. Wait **20-30 minutes** for the PAM to warm up. If you do not allow the PAM to warm up, you will get inaccurate readings.
9. The app picks up Bluetooth signals from any supported devices in the vicinity. Devices will pop up as either “Beacon” or “Direct Connect” based on the configuration of the device specified in its serial menu. Press the +” button to select the device you wish to view (identified by serial number).
10. The app will display the data being gathered in real time.
11. Press on a particular measurement to see info and a plot of its data.
12. Data are automatically collected into a file, which can be accessed via the closed-folder icon. Files may be exported or deleted.
13. Each time the PAM is powered ON, a new data file is created.
14. All data files can be viewed via the open-folder icon, and exported or deleted.
15. When you are finished with your measurements, power the PAM OFF.



- Home page: View real-time data.
- Plus icon: Select the device to view.
- Closed-folder icon: View the data files for the selected device.
- Open-folder icon: View all device files stored on your phone.
- To access “treks” data gathered by the PAM
- App info and tutorial.

D. Initialize Settings and Begin Measurements

This section of the manual describes how to establish the initial settings you want to use for your air sampling. Before you begin gathering data, make sure these settings are set correctly so your PAM will record and upload the data in the desired manner.

D.1 Clock Settings

The time on the PAM is set to UTC time via the GPS on the PAM and there is no need to “set” the clock unless you want the time to be output as local time. Also, if you are unable to connect to GPS for long periods of time, it can be set manually using the serial menu. Note that the manual setting will be overwritten when the GPS signal is regained.

D.1.1 Enter a Time Zone (to Output Local Time in the Data)

If you want your PAM data string to output in local time rather than UTC, use serial command “i” to enter a time zone. The time zone is an “offset” from UTC (for example, -7 for 7 hours behind UTC).

See <https://www.timeanddate.com/worldclock/timezone/utc> to find the offset for your time zone.

Remember to change this number to reflect changes in local time such as daylight savings time.

D.1.2 To Set the Clock Manually

If there’s no GPS signal for long periods of time, the PAM’s clock can be set manually through its serial menu:

- a) Follow the instruction in Section C.3 to connect your computer and access the PAM’s serial menu.
- b) Type “m” in the terminal emulator’s window on your computer to enter the serial menu.
- c) Type command “s” and then enter the time **in UTC** (see <https://www.timeanddate.com/worldclock/timezone/utc>).
- d) Type “x” to exit the serial menu. Verify the time and date at the end of the data line are accurate. Repeat the step above if a time adjustment is necessary. The format in the data line is YYYY-MM-DD and military time (hh:mm:ss).
- e) This manual clock entry will be overwritten when a GPS signal is regained.

D.2 Set the Data Upload Frequency of the PAM

The data upload frequency of the PAM (WiFi, cellular) can be specified by the user. You may wish to specify this in order to control cellular costs, for example.

- a) Follow the instruction in Section C.3 to connect your computer and access the PAM's serial menu.
- b) Type "m" in the terminal emulator's window on your computer to enter the serial menu.
- c) Type "e" to adjust the frequency for uploading data. The return line will say:

```
Enter new upload frequency
```

- d) Enter a value to choose how many seconds of data will be averaged and then uploaded. Hit the return key when you have typed the number. A readout will verify the old and new settings, for example:

```
The old UploadFreq value:  
300  
The new UploadFreq value:  
30  
Set new upload frequency to be: 30 seconds
```

- e) Type the command "x" to exit the serial menu.

D.3 Establish the PAM's Cellular Connection (if option purchased)

Cellular capability is an option for the PAM and must be purchased by the user when ordering the PAM. When the cellular capability is "enabled," the PAM's data are uploaded to the web via cellular, where they can later be viewed and downloaded for analysis.

The PAM's cellular is enabled/disabled through the serial menu. The mini-LED screen near the power button of the PAM cycles through to indicate the status of the cellular. If it is "enabled" and successfully connected, there will be no crosshatch through the cellular icon and the yellow LED will be illuminated (see below). A crosshatch through the icon indicates either that cellular is disabled, or that no cell signal is being received.

Section B.1 of this manual described how to verify that the cellular connection is established on your PAM. A brief summary is given below. Please refer to Section B.1 for further explanation.

- a) Once powered on, a green LED indicator (A) will go on to indicate that the printed circuit board for cellular is present and functional.
- b) The PAM will attempt to connect to cellular. Once it finds service, a yellow indicator LED (B) will go on.



-
- c) When the cellular connection is established, data are being transmitted to the Data Portal of the 2B Tech website: <https://2btech.io/>
 - d) If the yellow LED on the PAM never goes on, first move to another location to see if a cell signal is picked up. If not successful, check to be sure the PAM's cellular is "enabled." To "enable cellular" through the serial connection (Section C.3):
 - Follow the instruction in Section C.3 to connect your computer and access the PAM's serial menu.
 - Type "m" in the terminal emulator's window on your computer to enter the serial menu.
 - Then press "d" to enable or disable cellular. (You may wish to disable it in some circumstances to save on cellular expenses, for example.)
 - Enter command "x" to exit the menu.
 - e) If you are still unable to establish a cell signal, run the "debug" function through the serial menu (command "b" and then command "a"). This should give you information that will help you diagnose the problem.

D.4 *Connect to a WiFi Network*

All PAMs come with the capability to upload data using WiFi. Use the serial menu (Section C.3) to set up your connection to WiFi.

- a) Follow the instruction in Section C.3 to connect your computer and access the PAM's serial menu.
- b) Type "m" in the terminal emulator's window on your computer to enter the serial menu.
- c) Then press "g" to enable or disable WiFi.
- d) Type command "h" to enter your WiFi credentials. The PAM will scan for available networks. Selected the network and enter the password.
- e) Enter command "x" to exit the menu.

The mini-LED screen near the power button of the PAM cycles through to indicate the status of the WiFi. If it is "enabled" and successfully connected, there will be no crosshatch through the WiFi icon. A crosshatch indicates that it is either disabled or not connected to a network.

If the PAM does not connect, check your network functionality and/or the password. If you are still unable to connect to WiFi, run the "debug" function through the serial menu (command "b" and then command "n"). This should give you information that will help you diagnose the problem.

D.5 Power Up and Begin Measurements

After initializing your PAM in Steps D.1 to D.4, you are ready to begin measurements with the Personal Air Monitor.

1. Without powering on, plug in the PAM to its charger and plug the charger into a power source. Alternatively, plug the PAM's USB cable into a computer to provide power. Verify that the red LED comes on near the center of the PAM.



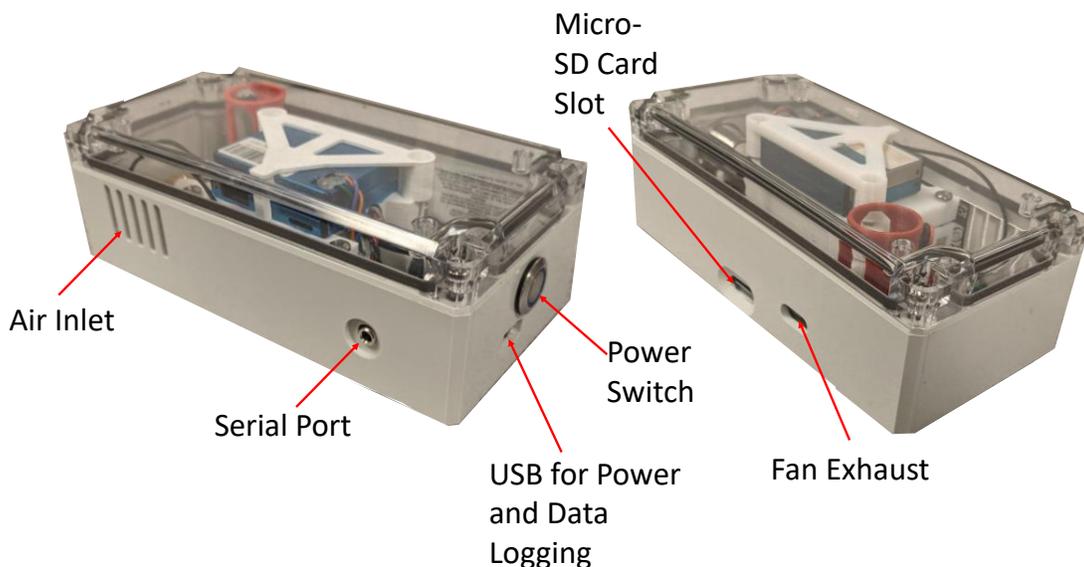
2. Locate the power switch for the PAM. Power on the PAM by pressing the button ONLY ONCE. After a short delay of a few seconds, the button will light up and the PAM will turn on. If the cellular option is present and enabled, verify its green and yellow LEDs are on as described in step 8 of Section B.1.



3. Be sure the PAM's inlet and exhaust (on the long sides of the PAM) are not obstructed.
4. The initial readings of CO and NO₂ are unreliable until the PAM is warmed up (~ 20-30 minutes).
5. Data are output every 3-4 seconds (if an NO₂ sensor is present on the PAM, the frequency is every 12-15 seconds to give better performance). See Section C of this manual for information on data viewing and downloading.

The PAM is designed to be used for mobile measurements, whether hand-held or mounted on a moving platform such as a vehicle. It can of course also be used for stationary measurements at a fixed site.

Keep in mind that the typical battery life of the PAM is about 6-8 hours. When used for fixed-site measurements, connect the PAM to a constant power source.



E. Periodic Zero Checks and Calibration

It is recommended that the user frequently examine the data from the Personal Air Monitor to be sure that the readings make sense and the sensors are working properly.

For example, on polluted days ozone readings should be higher, and other pollutants such as particulate matter might be higher (especially if fires are burning nearby, for example). Outside CO₂ readings should be around 400 ppm (inside readings can be much higher, depending on room occupancy, etc.). If an EPA monitoring station is located nearby, the PAM's outside readings could be compared to the station readings.

In addition to the above routine observations of the functioning of your Personal Air Monitor, the following checks and calibrations are recommended.

E.1 Zeroing and Calibration of the PAM

The zeroing, calibration, and occasional replacement of the PAM sensors are done at 2B Technologies, at a frequency that depends on the PAM's environmental sampling conditions. Contact 2B Technologies to discuss recommended scheduling.

E.2 Recommended: Frequent Checks of the PAM Sensor Functioning

It is advisable in all cases to observe the PAM readings and assess whether the values are reasonable for the local conditions. For example, comparing the PAM outside measurements to a nearby EPA-approved monitoring site would be a good way to check the readings. Other situational checks could be made on a routine basis. For example, the CO₂ sensor should read around 410 ppm outside during the day. It will give higher readings inside a room where people are present and CO₂ outdoors will also typically be higher at night. Near a combustion source like a busy highway, CO will be higher. Smoke and dust will lead to higher PM readings. For example, the smoke from an extinguished match or candle will provide a quick test of whether the PM sensor is functioning. If readings do not respond as expected for a given sensor, the sensor may be faulty. Please contact 2B Technologies for instructions and replacement parts.

F. Maintaining and Troubleshooting the PAM

F.1 Maintenance

The PAM requires no routine maintenance. However, it is recommended that the PAM sensors be checked frequently to verify that they are responding as expected, as described previously in Section E.2.

F.2 Troubleshooting

- If the PAM readings are noisy or do not seem to respond to changes in ambient air, be sure the fan airflow is not blocked. Keep the fan intake clear. It is located to the right of the micro-SD card on the side of the PAM. Also check to see that the fan wires are not disconnected from the printed circuit board (see Figure G.1, next page). If you power the PAM on and off, you should be able to see the fan blades start and stop spinning and you should hear the faint sound of it when running.
- If a particular sensor seems to be giving faulty readings or seems nonresponsive, check to see if it has become disconnected from the printed circuit board.
- During troubleshooting, it is best if the PAM is powered via the charger or via USB connection to a computer rather than its batteries.
- Be sure the all the cable connections to the PAM are secure.
- With firmware versions 2.0.0 and higher, the PAMs now support future firmware updates via the SD card.

F.3 Service through 2B Technologies

2B Technologies offers reasonably priced customer service for instrument repairs. 2B Technologies also offers calibration and service for the PAM. The best way to contact us for service is to log a customer service ticket at <https://2btech.io/support/>. Normally, you will hear back from us by email within a few hours. Or, call us at +1(303) 273-0559.

A great deal of technical information about our instruments is posted as [technical notes](#) on the 2B Tech website. Manuals, brochures, software, cleaning procedures and scientific papers may be downloaded at <https://2btech.io/downloads/>.

G. Labeled Instrument Photos

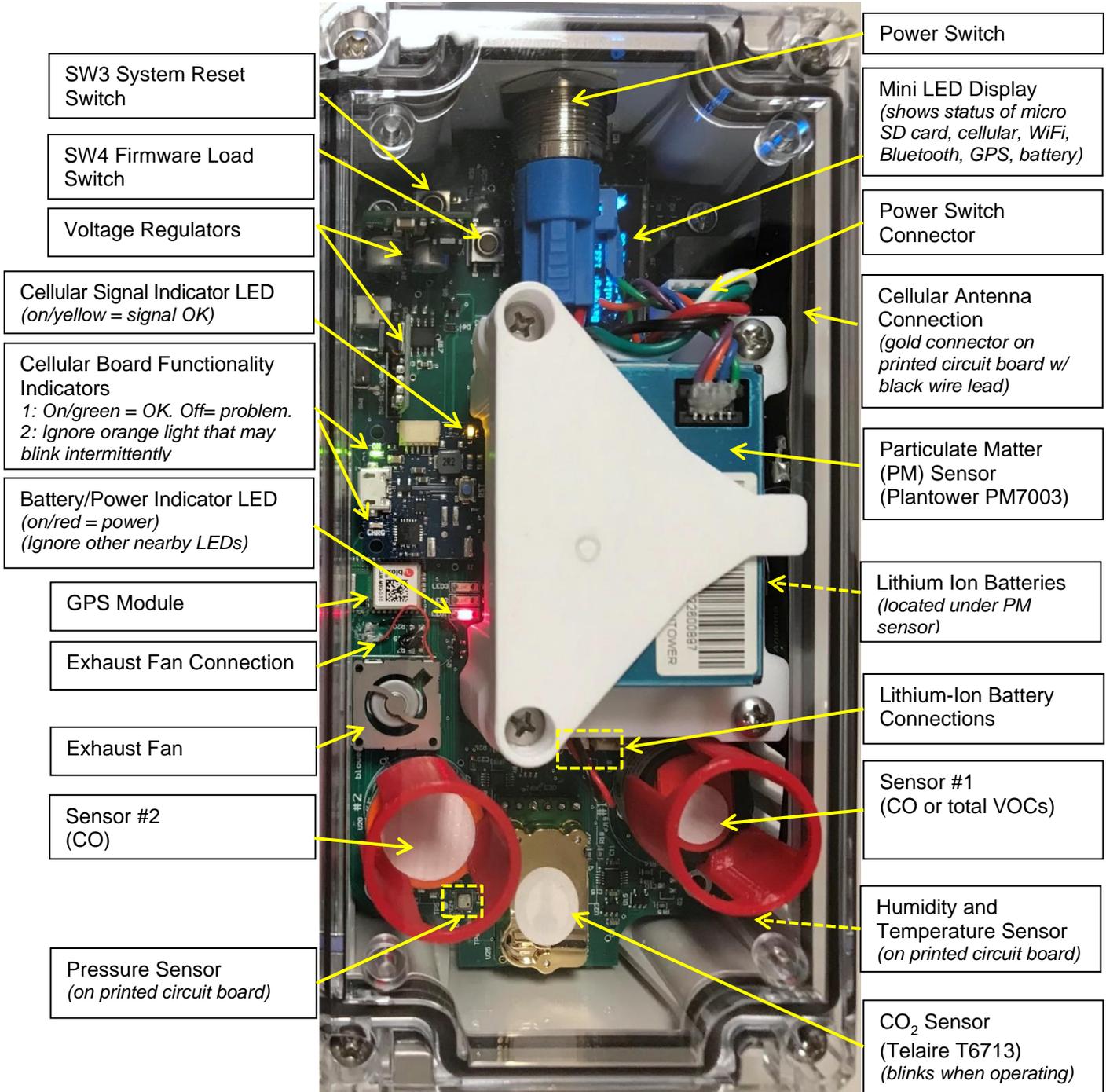
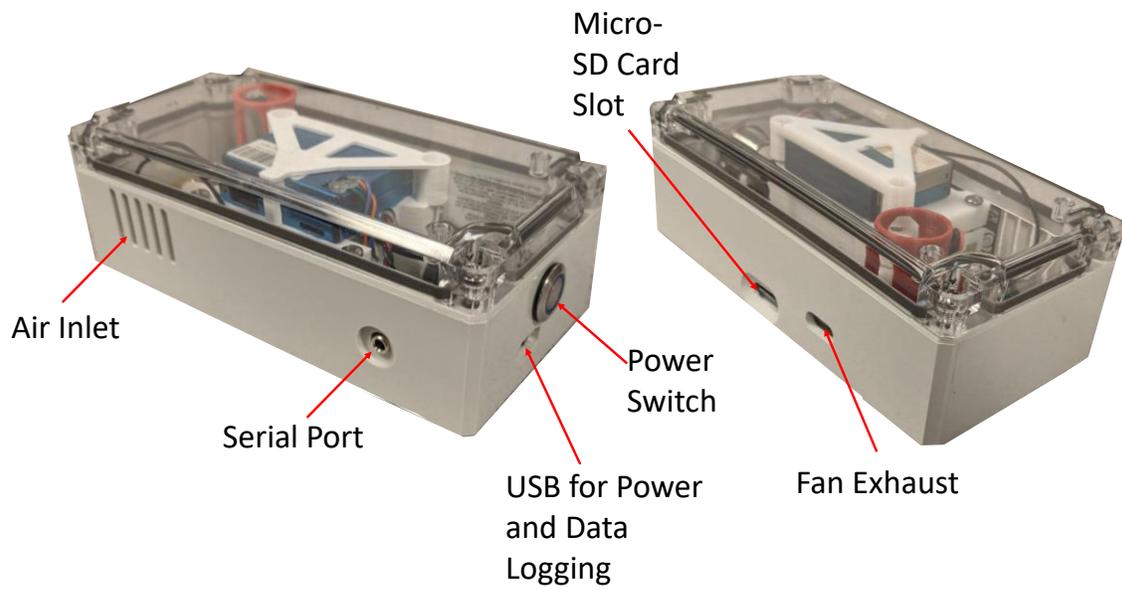


Figure G.1. PAM Top View (above) and Side Views (next page).

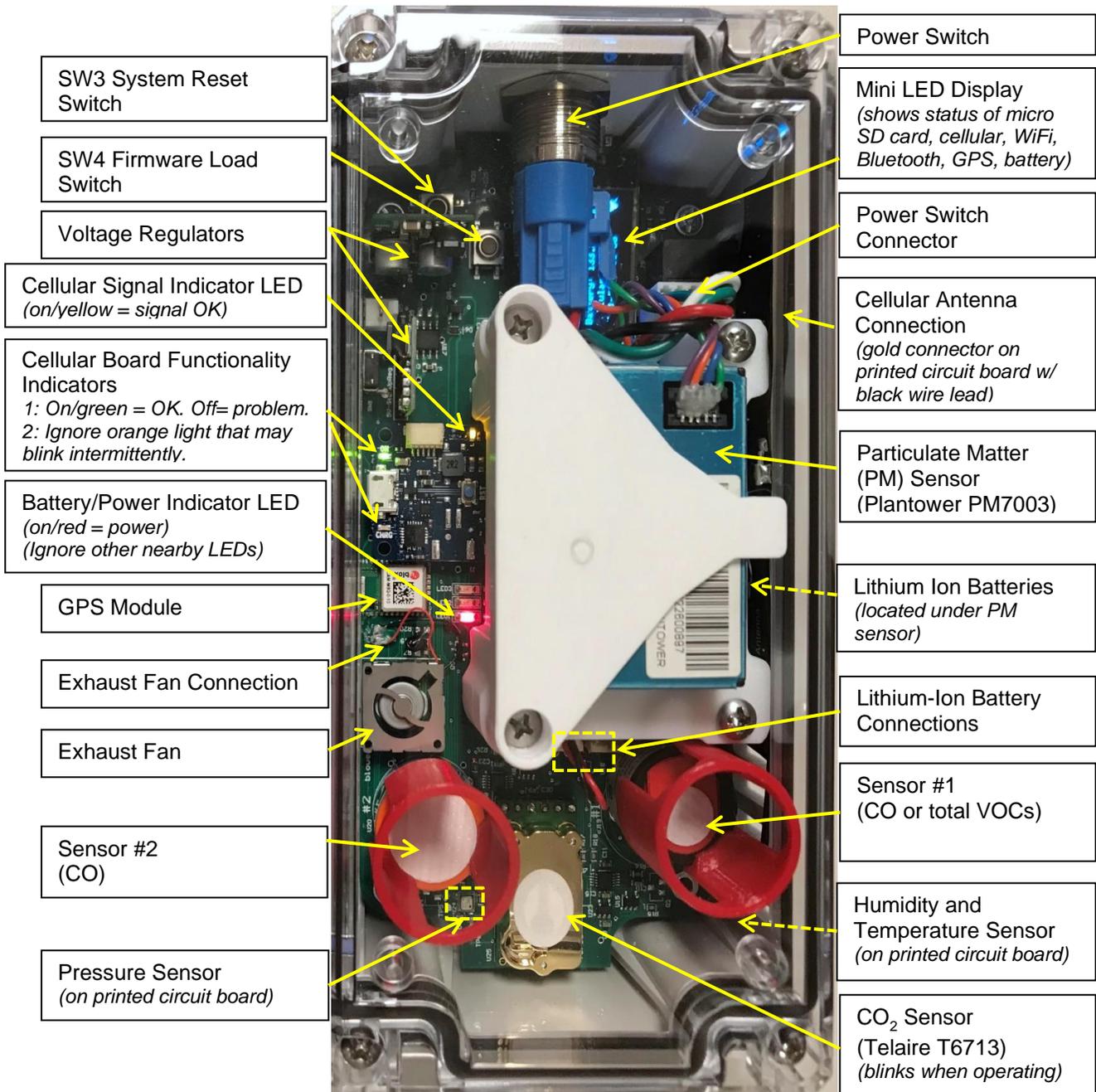


APPENDIX 1: Additional PAM Specifications

Overview

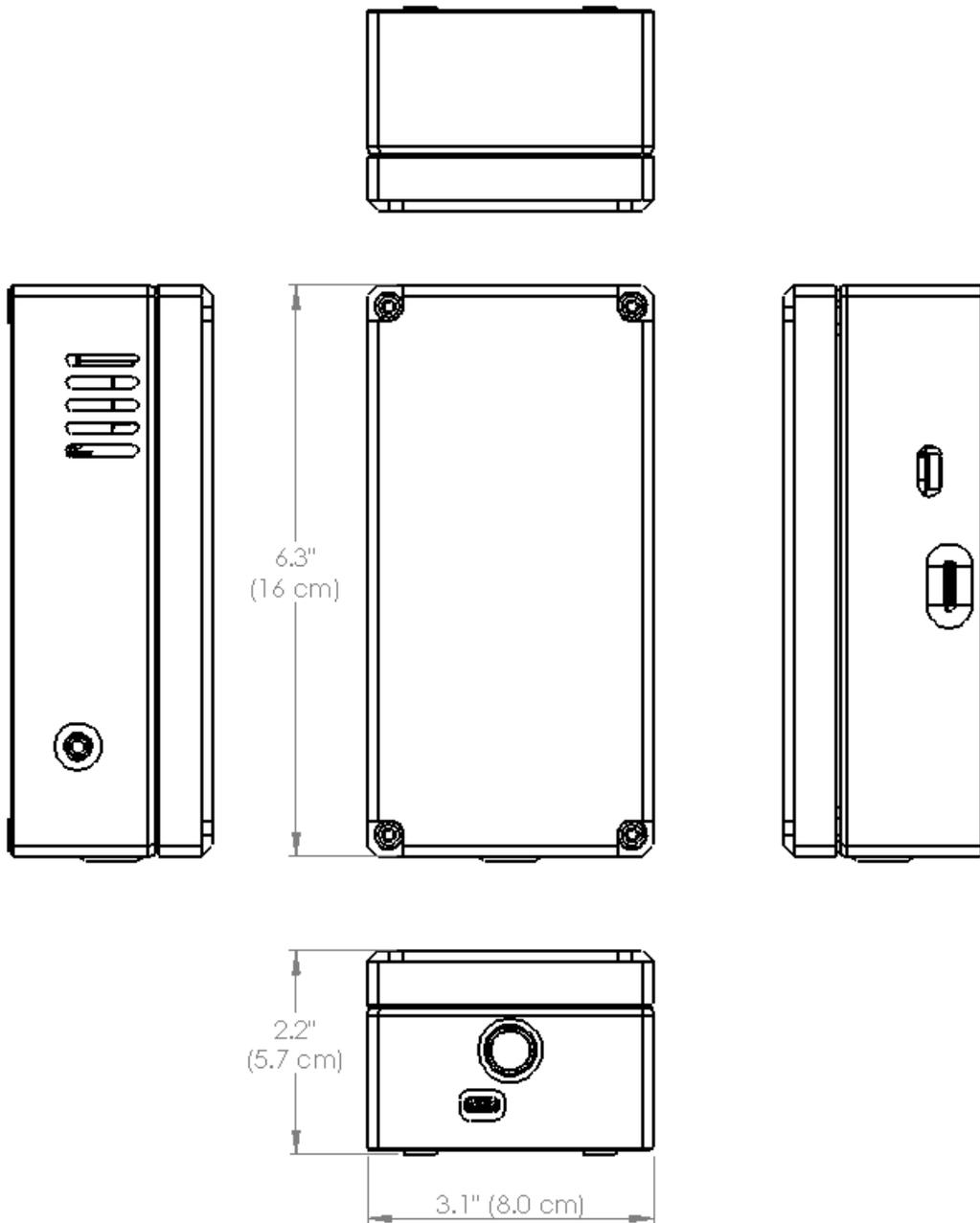
The Personal Air Monitor (PAM) contains sensors for the measurement of several air pollutants, along with pressure, temperature and relative humidity within the PAM enclosure. This Appendix gives additional technical information about the PAM.

The sensors and other components of the PAM are shown in the photo below. See the table later in this appendix for the manufacturers' sensor specifications.



Overall Specifications and Dimensional Drawings

Overall Specifications	
Weight	0.96 lbs (437 g)
Power Requirements	~0.2 amp at 12 V, 2.4 watt
Dimensions	6.3" L x 3.1" W x 2.2" H (16 cm x 8 cm x 5.7 cm)
Maximum Operating Temperature	45 °C



Sensor Specifications

Sensor Specifications (per manufacturer)	
Carbon Dioxide (CO₂) Sensor: Telaire T6713 (NDIR) Measurement Range: 0-5000 ppm Accuracy: 400-5000 ppm: ± 30 ppm, ± 3% of reading Response Time: < 3 min for 90% step change	Particulate Matter (PM₁, PM_{2.5}) Sensor: Plantower PMS7003 (Laser Scattering) Particle Size Range: 0.3-10 µm Mass Concentration Range: 0-999 µg/m ³ Count Accuracy: 50% @ 0.3 µm, 98% @ ≥ 0.5µm Response Time: < 10 s
Carbon Monoxide (CO) Sensor: Alphasense CO-A4 (Electrochemical) Response Time: < 30 s for a 10-ppm step change Precision: contact 2B Tech for information Measurement Range: 0-500 ppm	Total VOCs Sensor: ION Science Mini-PID2 HS (Photoionization) Measurement Range: 0 to 3 ppm Minimum Detection Limit: 0.5 ppb Response Time: < 12 s Sensitivity: > 600 mV per ppm
Pressure Sensor: Bosch BME680 Measurement Range: 300 to 1100 hPa Accuracy: ±1.0 hPa Resolution: 0.18 Pa Long-Term Stability: ±1.0 hPa per year	PAM Temperature and Relative Humidity Sensor: Honeywell HIH8120 (Platinum RTD/Capacitive) Measurement Range: 0-65 °C / 0 to 100 %RH Accuracy: ± 0.5 °C from 5 °C to 50 °C / ± 2 %RH Response Time (RH): 8 s

Power and Battery

The PAM is powered by two 3.7V 2000mAh lithium ion batteries and has a battery life of about 6 to 8 hours depending on cell uploading settings. Maximum operating temperature is 45 °C. Power is supplied through a USB-C cable from a wall charger or from a computer.

Printed Circuit Board

The PAM is built on a customized printed circuit board.

GPS Module

The GPS module is a U-Blox CAM-M8.

APPENDIX 2: Operation of PAM within Mobile Enclosure (“CarTopper” Mode)

2.A Overview

The Personal Air Monitor (PAM) can be operated within our mobile cartop carrier, the CarTopper™. Figure 2.1 shows the CarTopper enclosure with a PAM installed. The white aerodynamic plastic shell is mounted to the baseplate on a hinge. A 5V DC fan circulates air. Each CarTopper is equipped with a heavy-duty 10-foot (~3 m) USB-A to USB-C charging cable. The “A” end is plugged into a 5V USB charging port within the vehicle. The cable can be secured by rolling up the window. The blue Velcro strap keeps the PAM secured to the baseplate, and the white Velcro strap keeps the CarTopper closed. Four rubber feet containing magnets are used to keep the CarTopper securely attached to the top of the (steel) car roof without damaging the car’s paint.

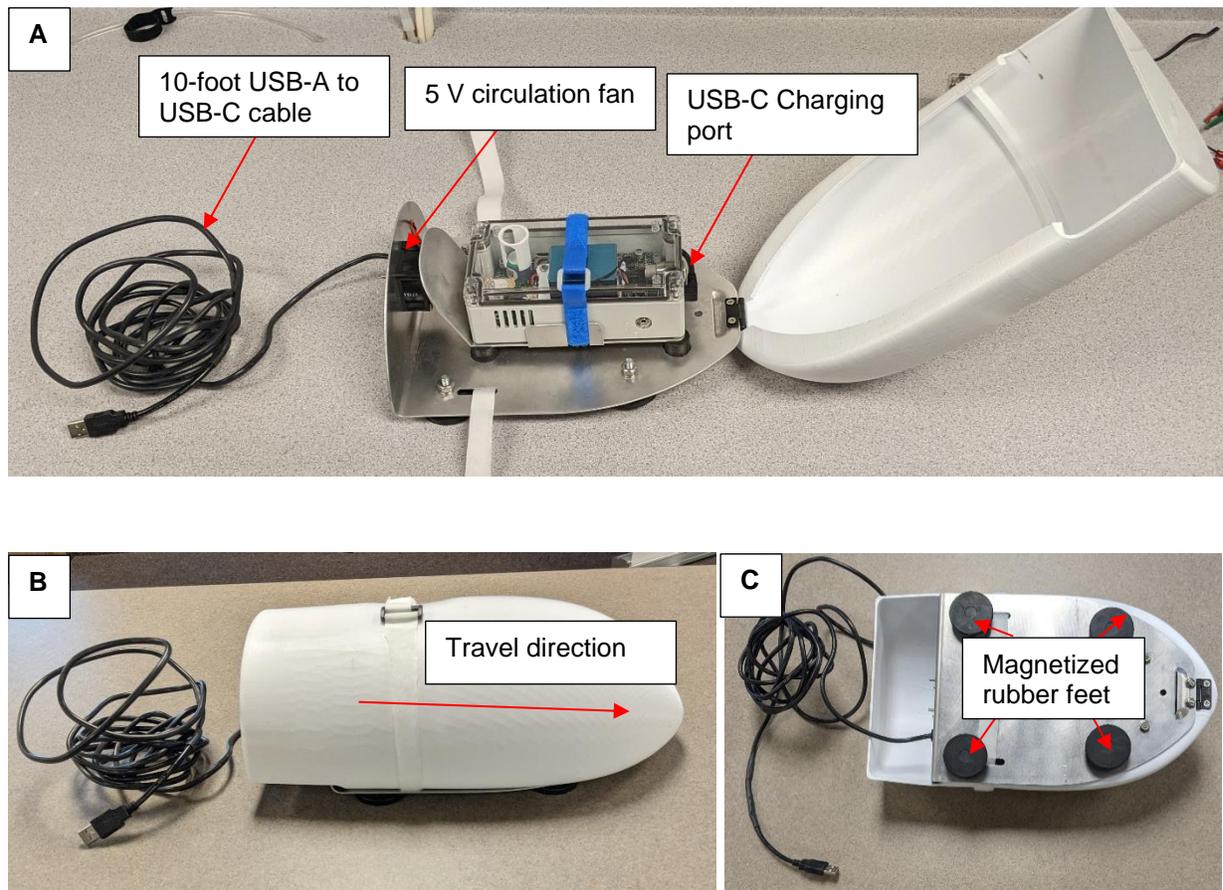


Figure 2.1. Panel A shows the PAM attached to the baseplate, the plastic shell opened, and the 10’ USB extension. Panel B shows the orientation of the CarTopper when in use. Panel C shows the magnetized rubber feet used to attach the CarTopper to the vehicle’s roof.

A schematic of the CarTopper is shown in the next figure:

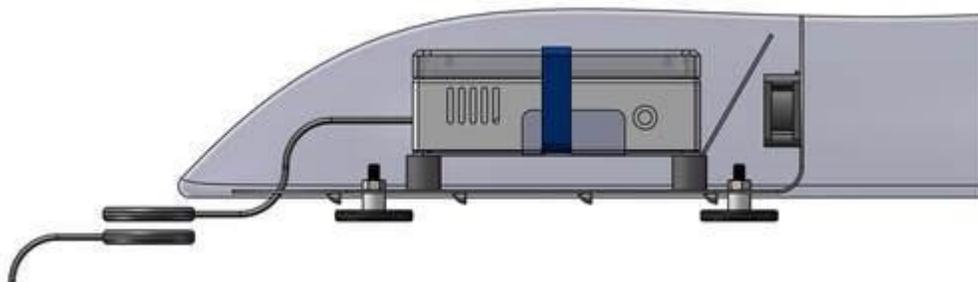


Figure 2.2. Schematic of the 2B Technologies CarTopper™ with the PAM in place.

2.B Instructions

1. Place CarTopper on the roof of the vehicle in the direction as shown in Figure 2.1a.
2. Ensure that the PAM is secured to the baseplate and USB-C cable is plugged into the PAM.
3. Plug the USB-A side into the vehicle's interior charging port. Route the wire as cleanly as possible to minimize any excess slack or cable movement.
4. Ensure that the CarTopper fan is running. Turn on the PAM's main power switch.
5. See other PAM instructions in Sections B and C of this manual.
6. **NOTE: If the user would like to take measurements and upload data *ONLY* when the vehicle is started, the PAM can be configured to "CarTopper mode" (see Section C.3). Enabling this mode will automatically turn off the PAM when there is no power at the USB charging port. The PAM will re-start when power is restored. This feature can be useful to eliminate excess data when the vehicle is turned off for extended periods.**

Figure 2.3 below shows a simplified electrical diagram of the vehicle's charging system and USB connections.

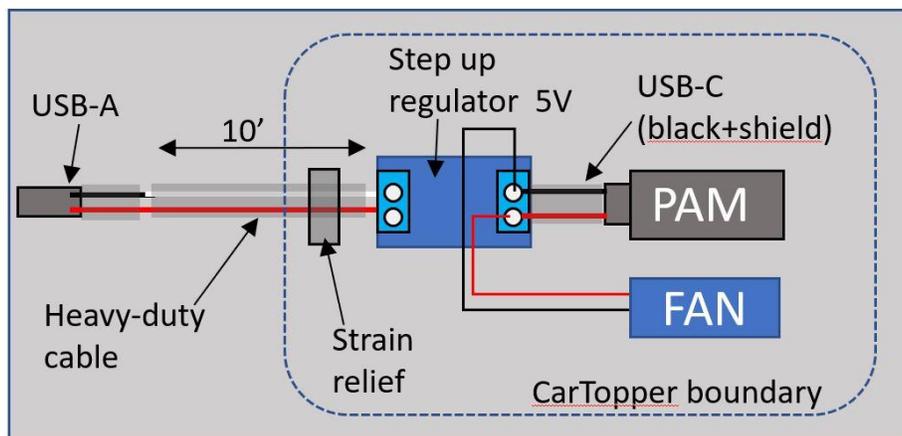
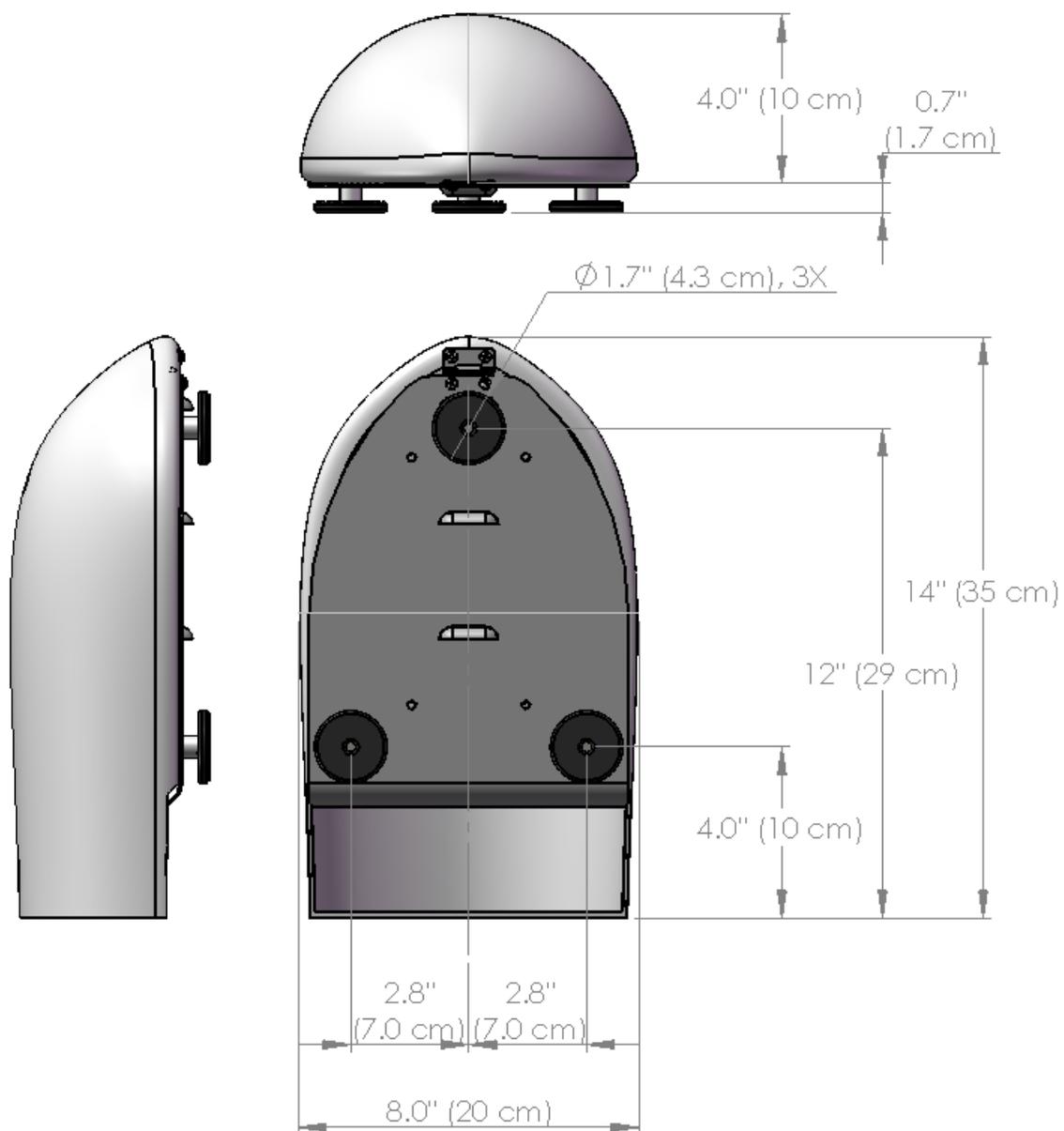


Figure 2.3. Electrical schematic of CarTopper and PAM features for use and battery charging.

2.C Specifications and Dimensional Drawings

Specifications	
Weight	3.4 lbs (1.5 kg)
Power Requirements	< 10 watt
Dimensions	14" L x 8" W x 4.7" H (35 cm x 20 cm x 11.7 cm)
Maximum Operating Temperature	45 °C



APPENDIX 3: Operation of PAM with Stationary Enclosure

The Personal Air Monitor (PAM) can be operated within a stationary enclosure for autonomous unattended operation. Figure 3.1 shows the stationary enclosure with a PAM installed. The power cable feedthrough is empty in this example, since the power source is customer dependent. It is typically either 120/240 V AC power or 12 V DC power.

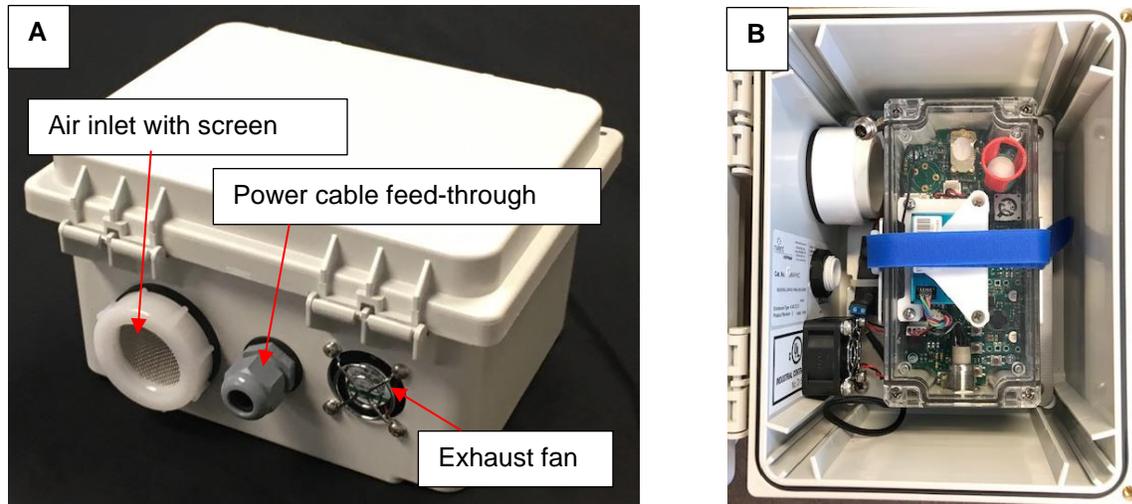


Figure 3.1. Panel A shows the rear portion of the stationary PAM enclosure with the exhaust fan, air inlet and power cable feed-through. Panel B shows the PAM inside the enclosure with the cover open.

3.A Instructions for Installing Power Cable for Inputting 12V DC to the PAM

1. Mount enclosure to a secure location so that it is vertical and the inlet and outlet ports are protected from rain and snow.
2. Locate cable-gland parts and separate them (threaded fitting with ring nut, rubber sleeve with slit, nut).

Cable-gland



Inside of nut, showing the rubber sleeve with slit



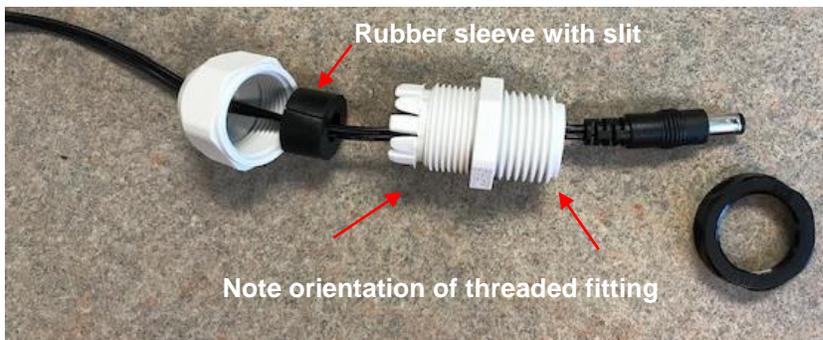
3. *If the rubber sleeve does not have a vertical slit in it, carefully use a utility knife or razor blade to make one.*



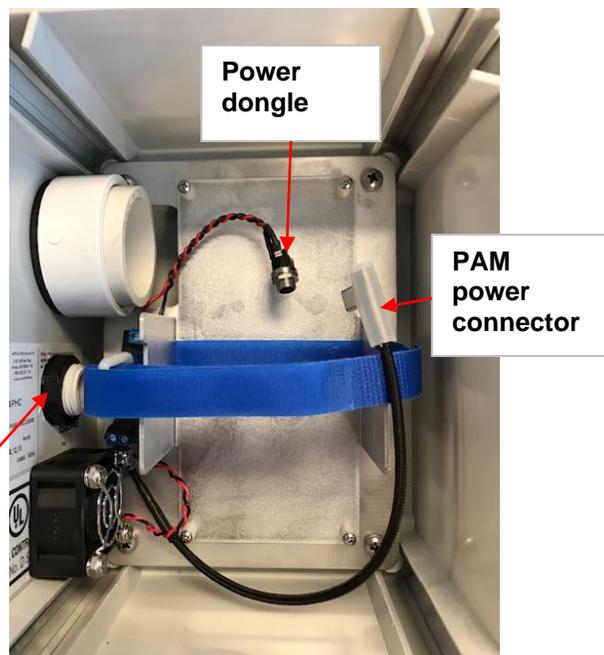
Vertical slit so sleeve can be opened and placed around wires

[Instructions below show the AC-to-DC power supply provided with your PAM. If you are using a different 12V DC power source such as a battery, install it through the cable gland in an analogous fashion.]

4. Insert the barrel connector from the power supply for the PAM through the nut, then through the body of cable gland. This should be done on the outside of the PAM enclosure. Place the rubber sleeve with slit around the wires as shown below.



5. Push threaded fitting through the hole in the enclosure from the outside of the enclosure, so the bulkhead of the threaded fitting is against the outside enclosure wall.



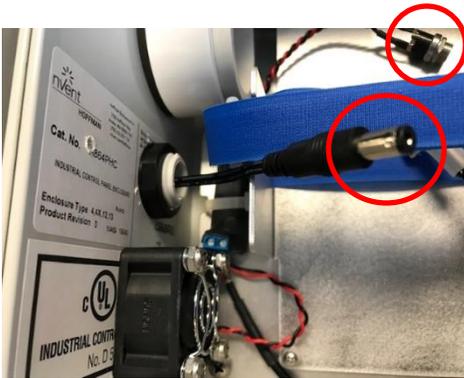
6. On the inside of the enclosure, put the ring nut on the threads, and tighten so that the threaded fitting is securely mounted to the enclosure.

7. On the outside of the enclosure, insert the rubber sleeve fully into the threaded fitting.

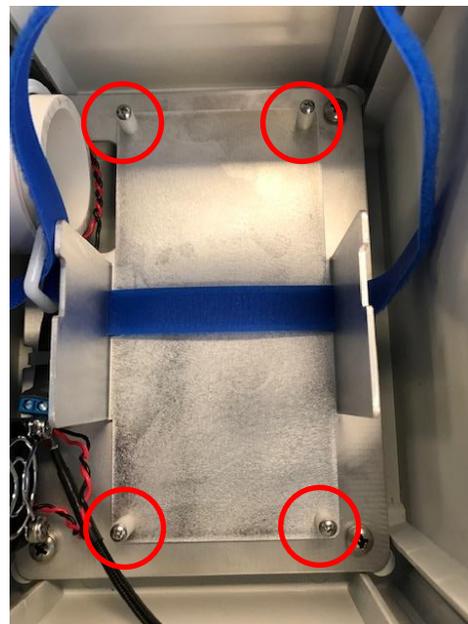
8. Fasten nut to the fitting.



9. Inside the enclosure, connect the barrel connector to the power dongle.



10. Undo the blue Velcro strap. Connect the PAM power connector to the PAM (left photo below). Carefully lower the PAM into the enclosure, being sure that the power connector is securely attached and also ensuring that the PAM is properly positioned over the four mounting posts in the enclosure (right photo below).



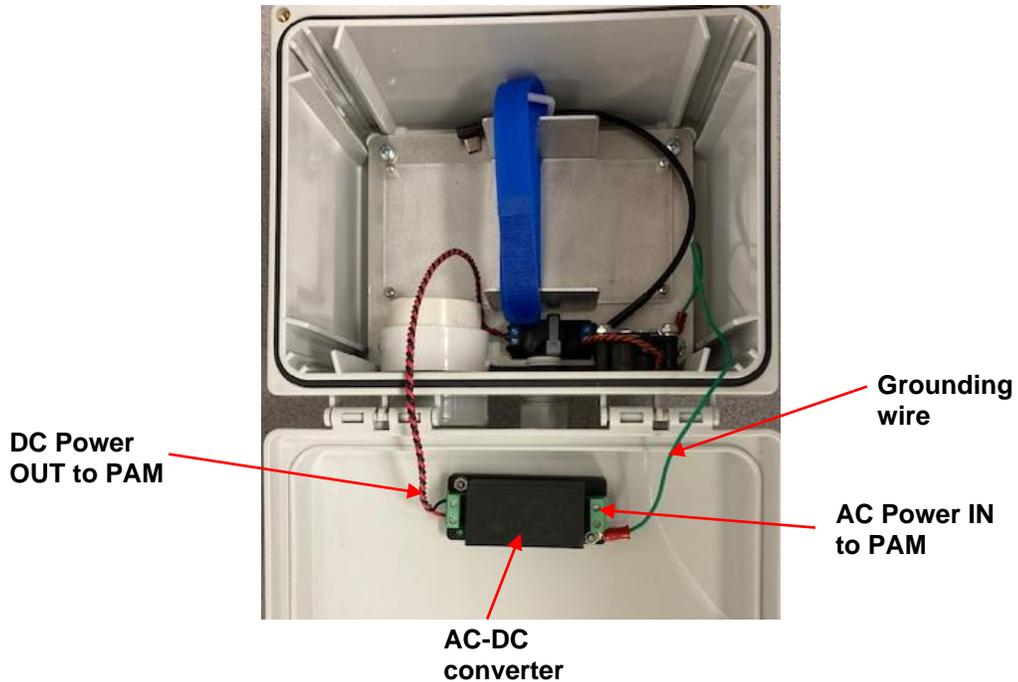
11. Secure the PAM with the blue Velcro strap.

12. Supply the appropriate power source to the enclosure. Ensure that the electrical connections outside the PAM enclosure are also protected from weather.

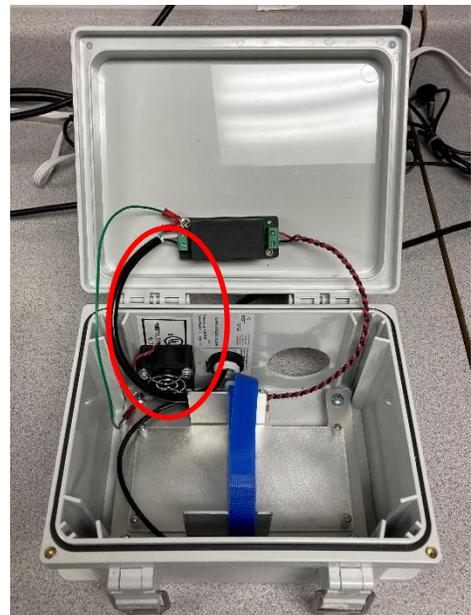
13. Turn on PAM using the main power switch.
14. Follow other instructions listed in Sections B and C of this manual.

3.B Wiring if Inputting AC Power to the PAM Enclosure

If your PAM has been ordered to accept direct AC input, it has been configured with an AC-to-DC converter on the inside front door of the enclosure. The converter is wired to the power board with a twisted black/red wire, and a green grounding wire is also installed:



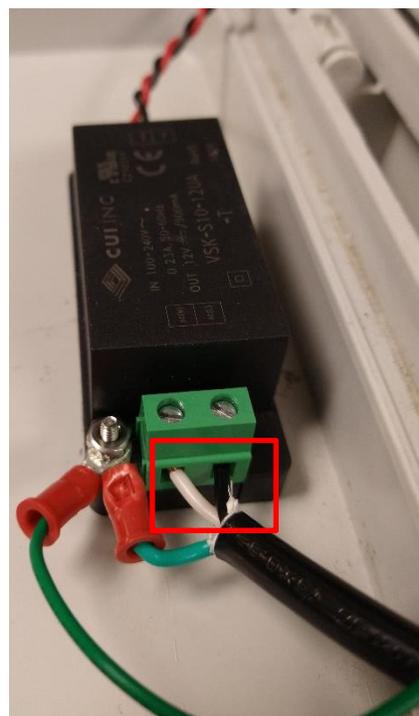
Install your AC input cable as shown in the picture at right, according to the steps and pictures that follow.



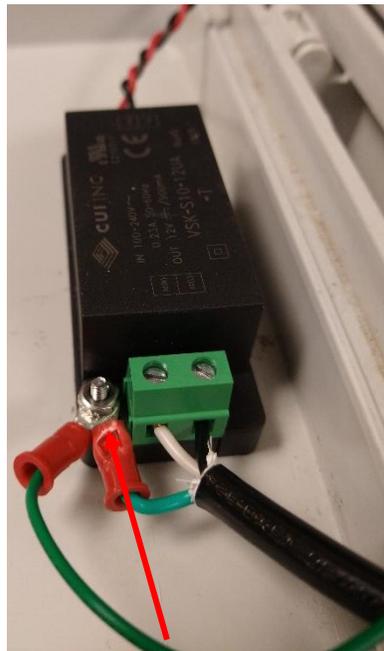
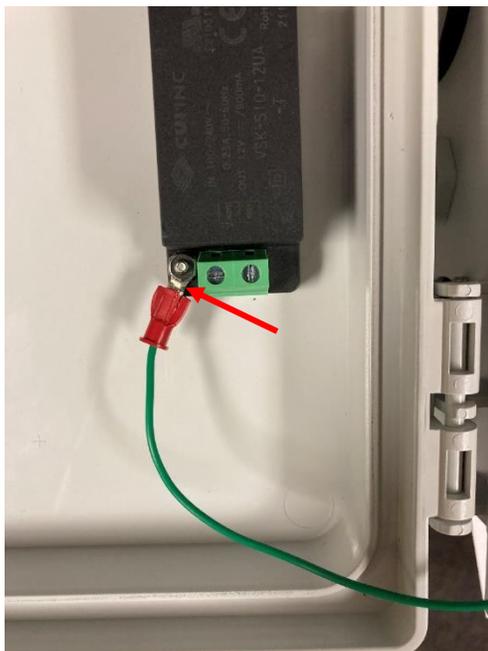
1. Remove ~1" of the black insulation from your AC input cable to expose the 3 wires. Also remove any metal foil shielding.
2. Strip ~1/2" off the ends of the 3 wires of the AC input cable (black, white, green).
3. Install a ring terminal on the green wire, crimping firmly to secure.
4. Install the AC input cable in the cable gland and into the enclosure as described in Section 3.A of this appendix, routing enough cable into the enclosure to permit connection to the AC/DC converter (about 11 inches).



5. Secure the white and black wires of your AC input cable onto the green 2-pin input terminal of the AC/DC converter as shown in the red rectangle below (note that the black wire is on the right of the white wire for the orientation of the photo here). Be sure to tighten firmly.



-
6. Install the green wire of your AC input cable in the same location on the converter as the green grounding strap that came installed on your instrument. Remove the nut, slide on the ring terminal of your green wire, and re-tighten the nut securely.

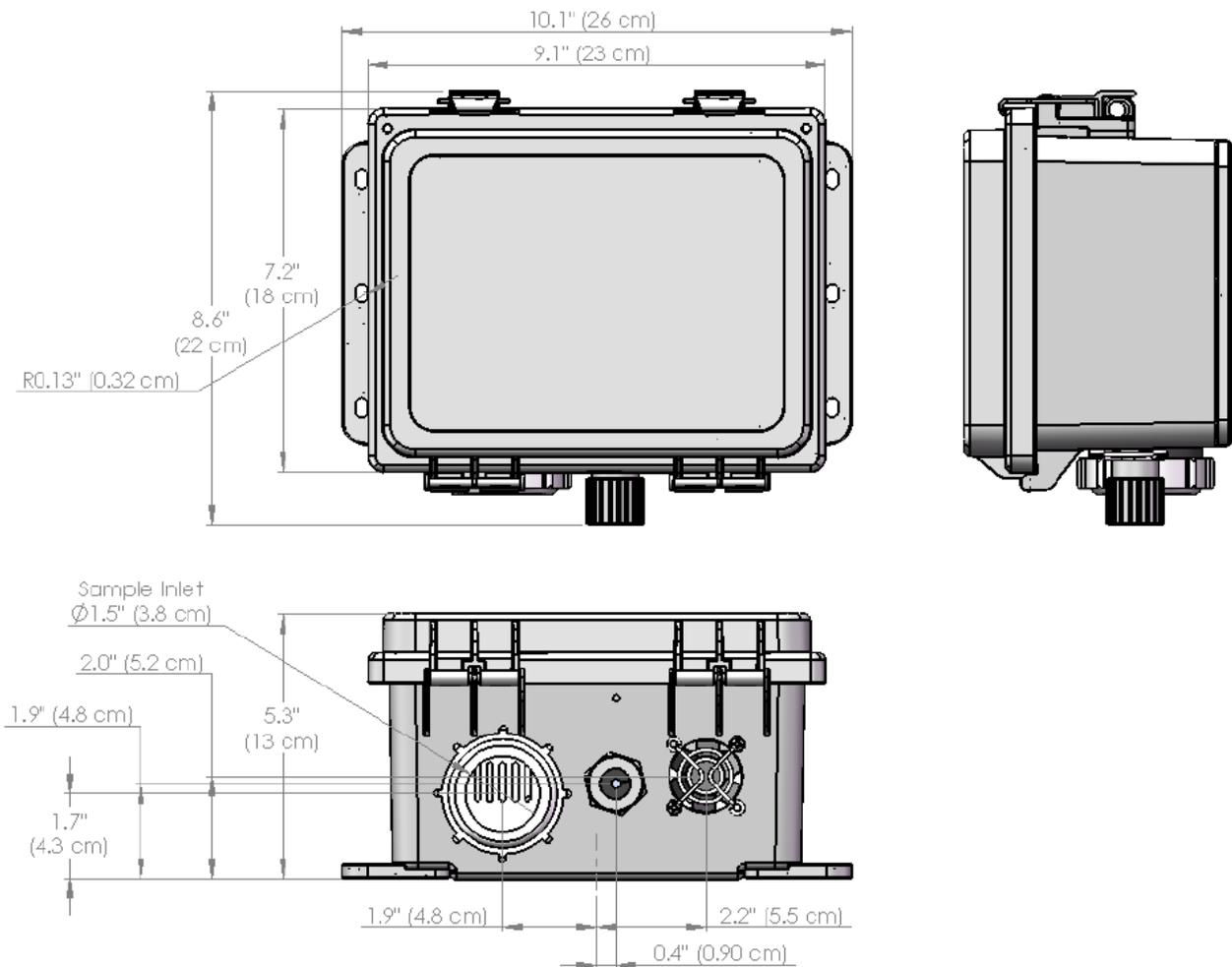


7. Confirm that your installation looks like the photo below.



3.C Specifications and Dimensional Drawings

Specifications	
Weight	3.9 lbs (1.8 kg)
Power Requirements	< 1 amp at 12 V, 10 watt max
Dimensions	10.1" H × 8.6" W × 5.3" D (26 cm × 22 cm × 13 cm)
Maximum Operating Temperature	45 °C



APPENDIX 4: AQTreks Smartphone App

We developed the “AQTreks” smartphone app for use with our first version of the PAM. It can also be used with the new generation of the PAM (in “Beacon” mode for Bluetooth). This app will display battery status, CO₂, CO, PM₁, PM_{2.5}, PM₁₀, T, RH, and P. Please note:

- The app will not display data for the TVOCs, SO₂, or NO₂ sensors that are available in some PAMs.
- The app cannot upload data.

The app is useful as a real-time check on your measurement conditions and the basic functionality of the PAM, and for storing data locally on your phone. Its use is described in this Appendix.

To gain additional functionality, we recommend using our new app, 2B Connect, described in Section C.4 of the main section of this manual.

Installation and Startup

The free “AQTreks” app for Android or iOS is available by searching for “AQTreks” in the app stores. Open the app while the PAM is running and choose the appropriate PAM identification. Verify that the PAM is operational and to view the data. When using the app, you must enable Bluetooth. Detailed instructions are below.

Newest Version of App:

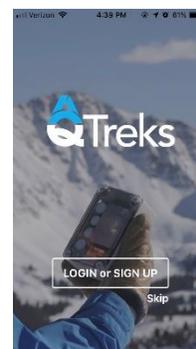
iOS: 3.16

Android: 6.9.7

NOTE: The version number can be identified by clicking the menu in the upper left-hand corner and looking at the bottom right-hand corner



- Download the AQTreks Smartphone application from the App Store (iOS devices) or Google Play (Android devices).
- **For Android users only:**
 - a. Go into your Android device’s settings.
 - b. Select “Location.”
 - c. Select “Mode.”
 - d. Select “High Accuracy” in location settings.
 - e. If you do not select high accuracy location mode, you may get a GPS error.
- Install the app. You must accept all permissions for the app to work correctly.
- Make sure Bluetooth is on.
- Open the AQTreks app.
- Select “Login or Sign Up.” (You can press “skip” to go directly to the measurement screens but you will not be able to upload data until you are logged in.)



- Select “Sign Up” at top of screen to create a new account.
- Enter your desired username and password. Or sign in with your Google account.
- Read and accept the AQTreks Terms and Conditions.
- Click “Sign Up”.
- Power on the PAM by pushing the silver button on the end of the instrument.
- Wait **20-30 minutes** for the PAM to warm up. If you do not allow the PAM to warm up, you will get inaccurate readings.
- The app automatically connects to the PAM. You should see the measurement screens and readings that are changing about every few seconds:



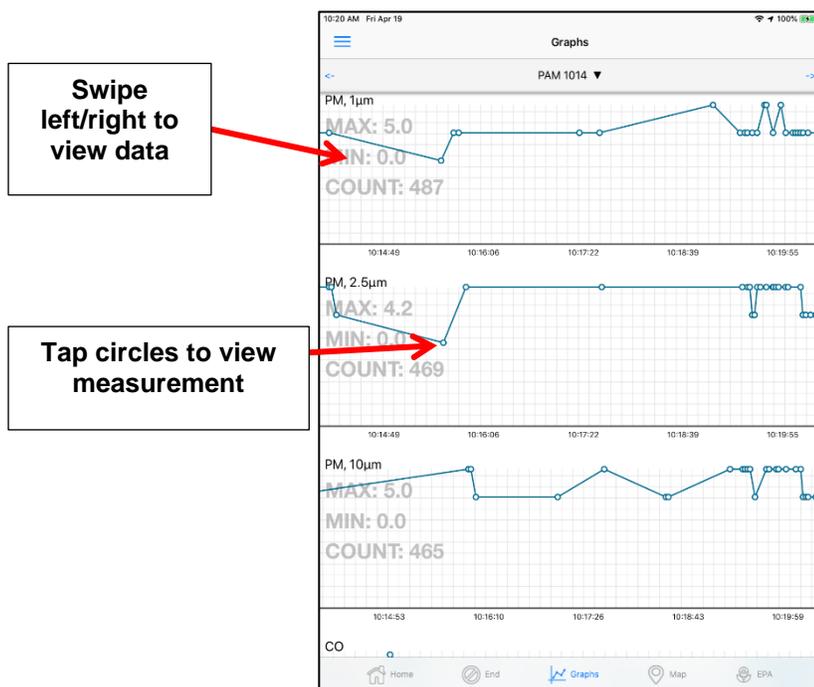
- Note that in this app, your data-gathering session is referred to as a “Trek.”
- When you are finished with your measurements, go to the “End” tab.

Explanation of the Screens

- 1. Home Screen:** The home screen shows the current air pollution concentrations. You can scroll down to view all the measurements.
 - a. Tapping the “i” icon within each box will bring up information about each measurement.
 - b. The colors of each measurement are related to the AQI scale. The meaning of each color is listed at the bottom of the screen. (Note: “USG” stands for “unhealthy for sensitive groups”).

2. Graph Screen: The graph screen (see next page) exhibits the air pollution concentrations in relation to time.

- a. You will see a list of the individual air pollutant graphs with your measurements over time. You can swipe left or right on each graph to view past or present measurements.
- b. You can see how many data points have been collected for each pollutant by viewing the gray “count” number in the background of the graphs.
- c. You can view the maximum and minimum values measured for each air pollutant in the background of the graphs.
- d. To see a detailed measurement number, tap on a point within a graph.



iOS App Graph Screen

3. Map Screen: The map screen exhibits air pollution data points overlaid onto a Google map in correlation with GPS points collected by your mobile device.

- a. The bubble on the bottom of the map screen will pull up a screen listing all of the species measured by the PAM. Click on the circle to the left of each air pollutant species to make that species active in the map view and click “Done”.
- b. Individual data points will appear on the map.
- c. You can click on individual data points to see air pollutant concentrations at certain times.
- d. To leave a comment or attach a photo on a certain data point:

-
- i. **iOS users:** tap the GPS data point. A comment box will appear. Type your comment and click “Save.”
 - ii. **Android users:** tap on the GPS data point. Then tap on the data box pop-up. A comment box will appear. Type your comment and click “Save.”

Photos and comments are stored locally on your phone and can be viewed in your saved Treks.

4. Regulatory Data Screen: The EPA Status Screen shows air pollution and weather data from the regulatory reference station nearest to your PAM’s location.

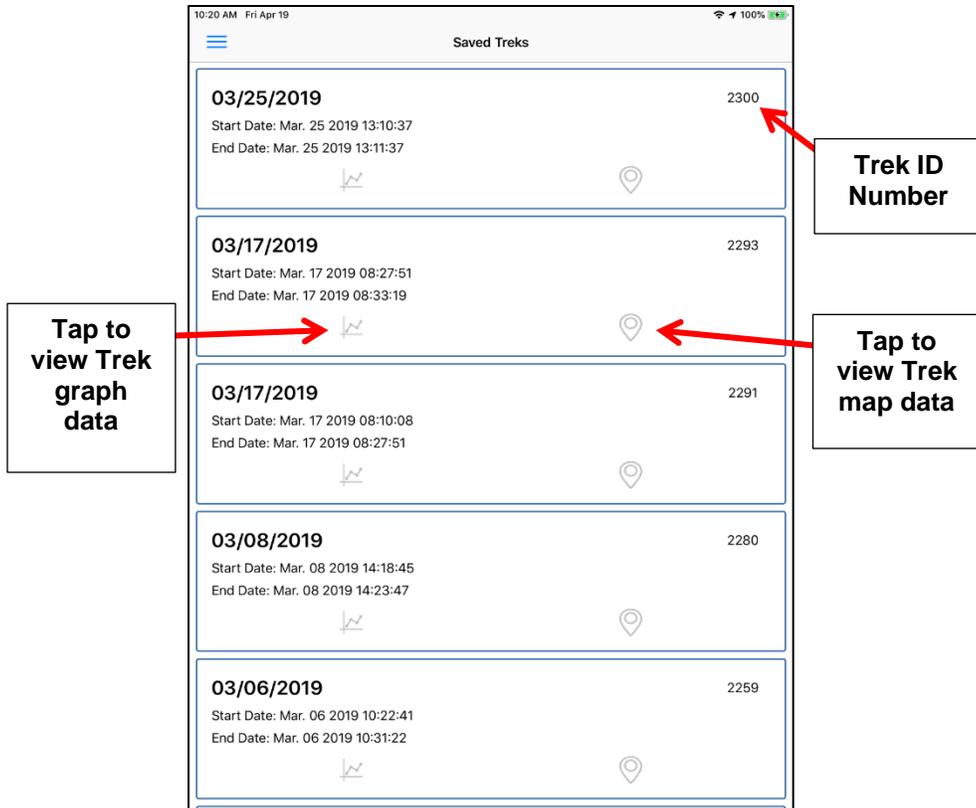
- a. The left-hand column represents the regulatory reference station’s data. To see the location of the reference station for the parameter you are interested in, click the current measurement. This will bring you to a map showing your current location in comparison to the reference station.
- b. The right-hand column represents your PAM’s data.

5. End Trek Screen: When you are finished taking data, go to the “End” tab.

- a. Click “Save and End Trek”. (Note that your data session is referred to as a “Trek” in this app.)
- b. Your Trek is saved on the main page under the “History/Saved Treks” menu tab. You can view your Trek at any time.
- c. Note that the data cannot be uploaded from your phone. Data uploading from the PAM is achieved with either cellular or WiFi, and data access is via the 2B Tech Data Portal on our website. Please see other sections of this manual for information.

6. Menu: The menu tab is located in the upper left-hand corner; tap to open.

- a. **Home** – Will bring you back to the home page showing the air pollution measurements.
- b. **Saved Treks** – Shows the historical Treks that you have ended and saved.
 - i. Treks are listed by date.
 - ii. If you tap the graph or map icon for each Trek it will take you to these screens for that Trek data.
 - iii. Note: if you delete the app, you will lose your saved Treks.



iOS App Saved Treks Screen

- c. **About Us** – Tapping this option will bring up a screen that says “Leaving. You are about to leave the app. Would you like to continue” Tap yes or no. Tapping yes will take you to our CommunityAQ About webpage.
- d. **Help** – General help points about the app
- e. **Device Info** – Tapping this option will bring up a screen that describes your PAM device number and status.
- f. **Log In** – Will enable you to log into the app.
- g. **Log Out** – Will log you out of the app and take you back to the sign-in page.