

microAeth®

MA Series MA200, MA300, MA350

Operating Manual

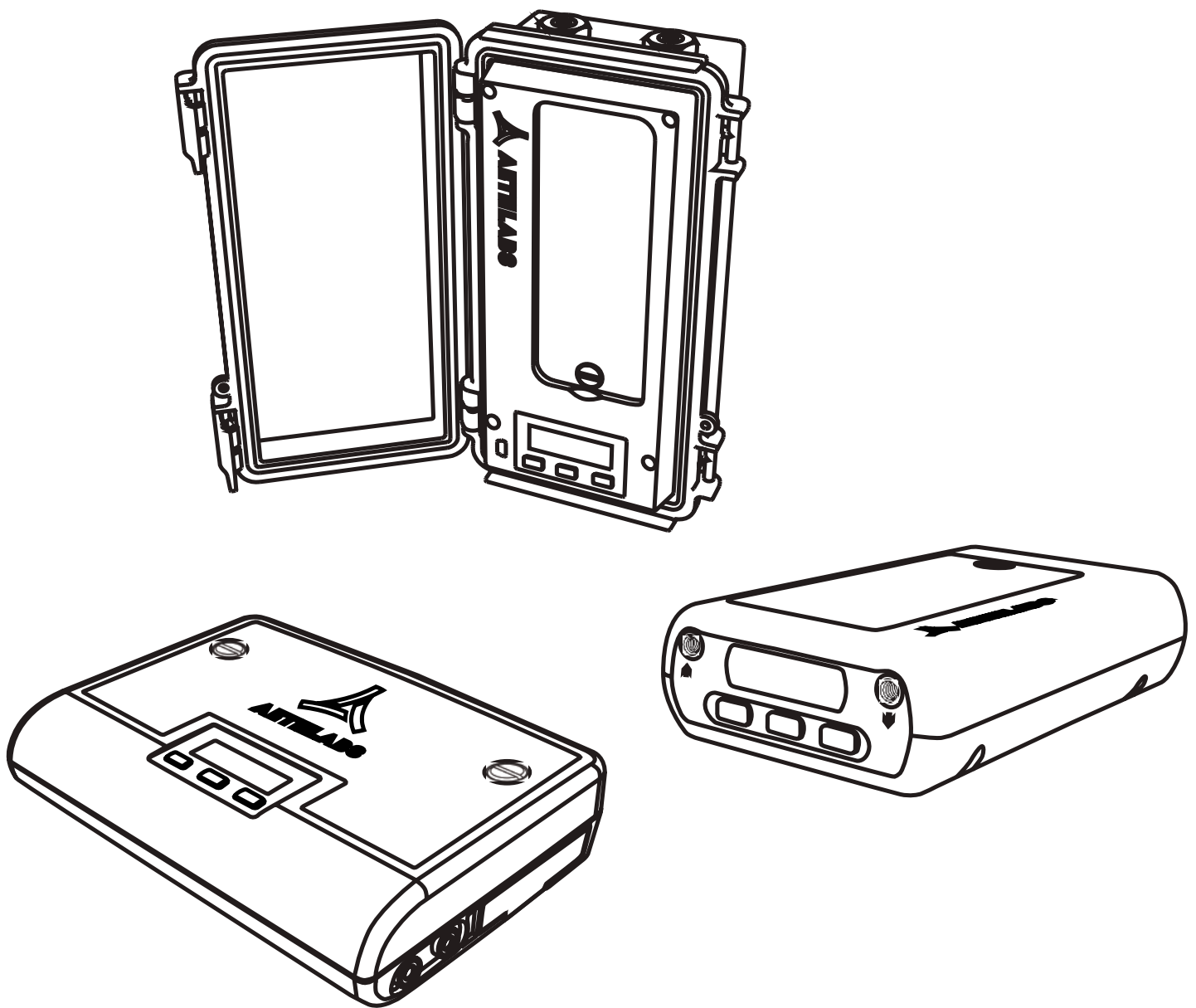


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1. Introduction

1.1. Serial Number

The model and serial number of the microAeth MA200 and microAeth MA300 are located on the bottom and back of the instruments adjacent to the USB port. The model and serial number of the microAeth MA350 is located on the inside of the main enclosure door of the instrument adjacent to the USB port. Record the serial number in the space provided below. Refer to these numbers whenever you contact AethLabs for service.

Model: microAeth® MA_____

Serial Number: MA_____ - _____



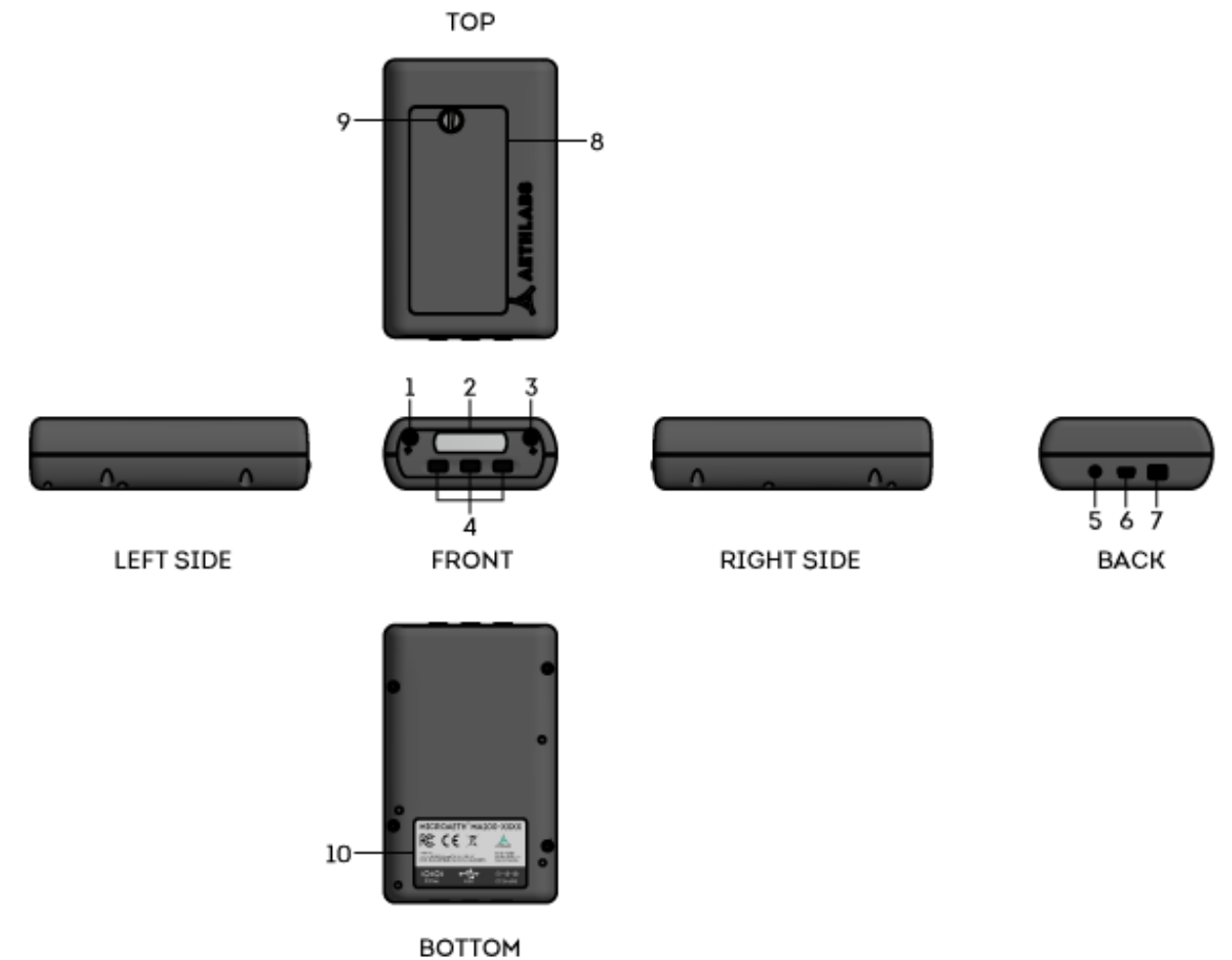
1.2. Overview

Thank you for your purchase of the AethLabs microAeth® Black Carbon monitor. This product is the result of many years of research and development and represents a leap forward in mobile and stationary Black Carbon measurements. We hope that the features and capabilities of this product will enable new types of research and scientific inquiry. Please let us know how you use the instrument and if there is anything we can do to help.

The microAeth MA Series instruments are portable scientific instruments which measure the mass concentration of light absorbing carbonaceous particles in a sampled aerosol. The instruments have 5 analytical channels each operating at a different wavelength (880 nm, 625 nm, 528 nm, 470 nm, 375 nm). Measurement at 880 nm is interpreted as concentration of Black Carbon ('BC'). Measurement at 375 nm is interpreted as Ultraviolet Particulate Matter ('UVPM') indicative of organic sources such as woodsmoke, tobacco, and biomass burning. The MA Series instruments have a number of important advancements. The microAeth MA Series feature miniature cartridges that have a spool of filter material for particulate collection and on-board analysis. The instrument automatically controls the advance of the tape material, moving to a new unused spot when required. This allows the instrument to run continuously for multiple weeks or months without human intervention. The 5 wavelength optical engine enables discrimination between organic and elemental particles which is helpful in source identification when measuring different aerosols. The MA Series also features the DualSpot® loading compensation method, which in real-time measures and adjusts for differing optical properties of particles of varying age and composition.

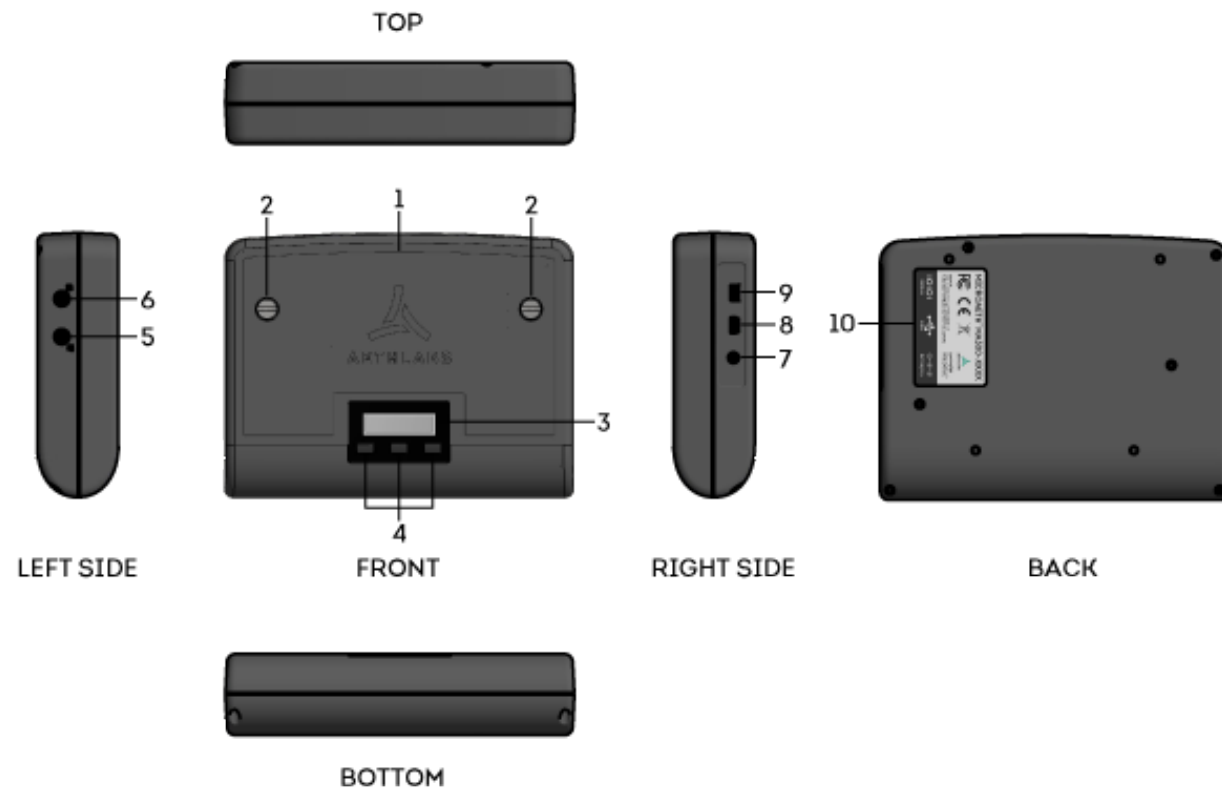
1.3. Instrument Diagrams

1.3.1. MA200



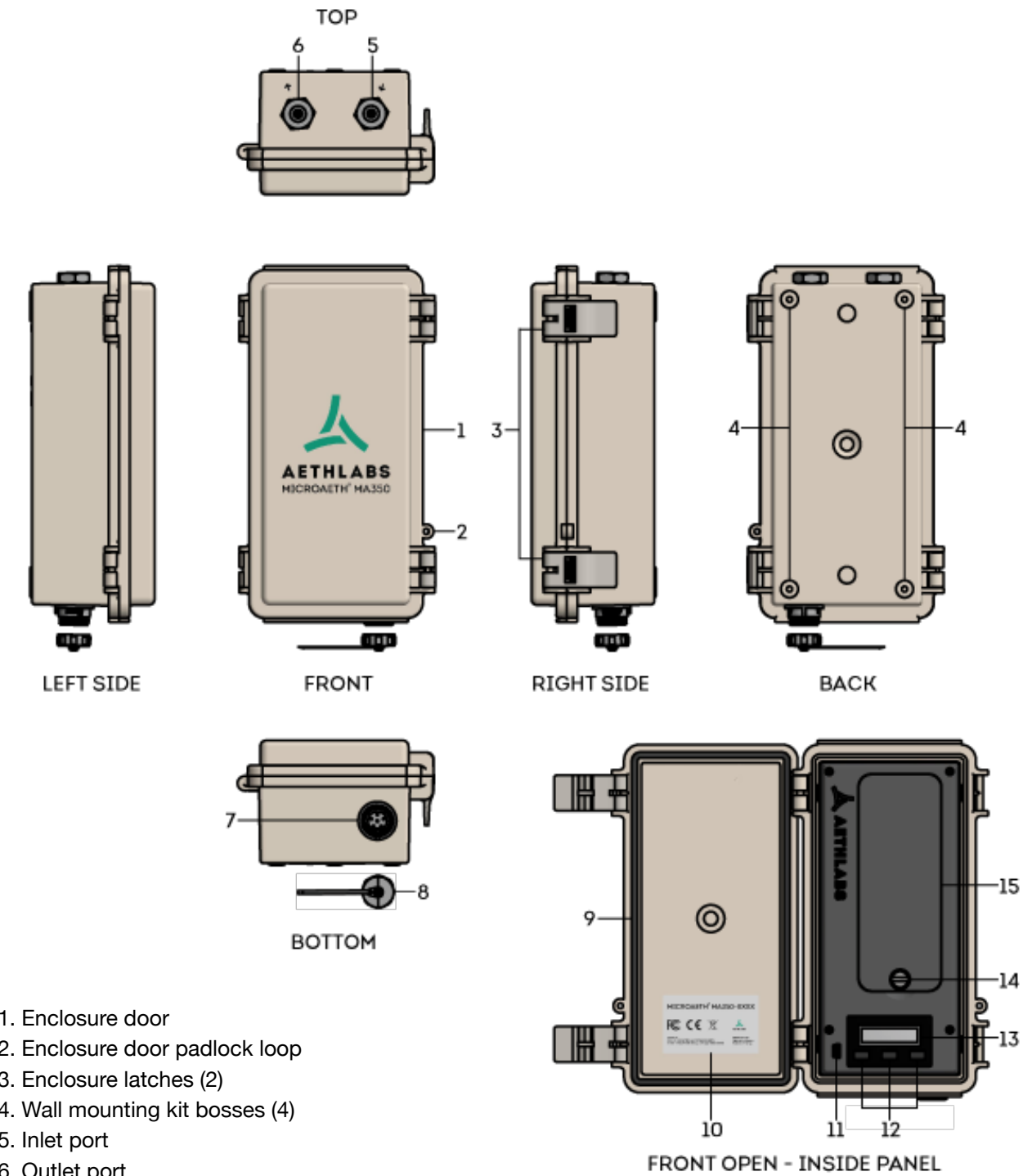
1. Inlet port
2. User interface screen
3. Outlet port
4. User interface buttons (3)
5. DC Barrel jack port
6. USB mini-B port
7. 4-pin 3.3V TTL serial port
8. Filter tape cartridge door
9. Flat head screw in filter tape cartridge door
10. Serial number label

1.3.2. MA300



1. Filter tape cartridge door
2. Flat head screws (2) in filter tape cartridge door
3. User interface screen
4. User interface buttons (3)
5. Inlet port
6. Outlet port
7. DC Barrel jack port
8. USB mini-B port
9. 4-pin 3.3V TTL serial port
10. Serial number label

1.3.3. MA350



1. Enclosure door
2. Enclosure door padlock loop
3. Enclosure latches (2)
4. Wall mounting kit bosses (4)
5. Inlet port
6. Outlet port
7. Sealing circular connector for DC power in, 3.3V TTL serial comms
8. Cap for sealing circular connector
9. Enclosure door gasket
10. Serial number label
11. USB mini-B port
12. User interface buttons (3)
13. User interface screen
14. Flat head screw (1) in filter tape cartridge door
15. Filter tape cartridge door

2. Safety, Handling, and Support

2.1. Important Safety Information

WARNING: Correct operation of the microAeth is imperative for safe functioning. Failure to follow these safety instructions could result in fire, electric shock, injury, or damage to the microAeth, accessories, or other property. Only AethLabs authorized service personnel should remove covers except filter tape cartridge door. Never disassemble or make modifications to the microAeth as it may cause damage or hazard. Read all safety information and familiarize yourself with the contents of this user manual before using the microAeth.



2.1.1 Handling

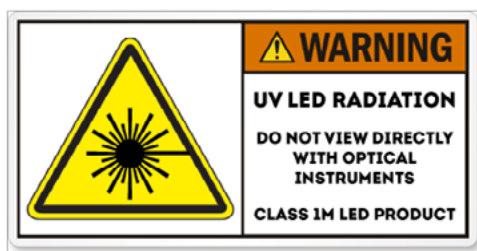
Please handle the microAeth with care. The microAeth has sensitive electronic and mechanical components inside that if disturbed or damaged can cause measurement issues and possible hazard. The microAeth and its lithium-ion battery can be damaged if dropped, impacted, burned, punctured, crushed, or exposed to liquid. If damage is noticed or suspected, discontinue use of the microAeth and any accessories until the instrument has been inspected or repaired by AethLabs authorized service personnel.

2.1.2. Repair

Only AethLabs authorized service personnel should repair or service the microAeth. Never disassemble the microAeth for any reason including repair. Never remove covers except for the filter tape cartridge door. Always make sure the filter tape cartridge door is reinstalled when the instrument is in use. Making modifications or repairs to the microAeth will void any warranty and may cause damage or hazard.

2.1.3. Light Sources

The microAeth contains components with emissions in both the visible (red, green, and blue) and invisible spectrums (infrared and ultraviolet). These components are covered during operation and not directly accessible but can cause injury and damage if unauthorized disassembly or repair is made to these sources or any of their mating components. Do not look directly at the light sources as it may be hazardous to do so with the naked eye or with the aid of optical instruments. The microAeth contains a Class 1M LED light source product. Do not directly view the light sources with optical instruments. Only AethLabs authorized service personnel should move, modify, service, or repair the light sources and mating components.



2.1.4. Battery

Do not attempt to disconnect, connect, or replace the lithium-ion battery in the microAeth. Do not expose the battery to sources of excessive heat. Only AethLabs authorized service personnel should service or replace the battery in the microAeth. Never remove covers except for the filter tape cartridge door. Always make sure the filter tape cartridge door is reinstalled while the instrument is in use. The lithium-ion battery in the microAeth must be recycled or disposed of properly and separately from general or household waste in compliance with local laws and regulations. The lithium-ion battery contained in the microAeth and therefore the microAeth must be packaged and shipped properly. Please see section 2.2.11. Shipping for more information. Do not incinerate the battery. Do not handle damaged or leaking lithium-ion batteries. **CAUTION RISK OF EXPLOSION IF BATTERY IS REPLACED BY AN INCORRECT TYPE.**

2.1.5. Charging / Power Source

The microAeth should only be operated and charged from the power source types indicated in the instrument specifications. Charge and operate the microAeth with the supplied power barrel jack for fast charging or the supplied USB cable for charging over USB. Only genuine cables and power chargers from AethLabs should be used. Do not use any cables, power chargers, or power sources with the microAeth that are not supplied by, or recommended by AethLabs, as they may cause damage or a hazard. Always inspect ports and cables before making any connection to the instrument. Damaged cables or chargers, or charging when moisture is present, can cause fire, electrical shock, other injury, or damage.

2.1.6. Heat Exposure

Do not expose the microAeth or its battery to sources of excessive heat such as direct, high intensity sunshine or fire. Always provide adequate ventilation, shelter, or protection for the instrument.

2.1.7. Radio Frequency Exposure

The microAeth uses radio signals for wireless communications with networks and other instruments.

2.1.8. Radio Frequency Interference (FCC and IC Compliance Statements)

The effect of electromagnetic fields from components and radios contained in the microAeth on other electronic devices is dependent on various factors and is unpredictable. The microAeth complies with Part 15 of the FCC Rules and with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Do not use near life critical systems. The electromagnetic fields from the instrument may interfere with other electronic devices. Follow all signs and notifications that prohibit or restrict the use of electronic devices and wireless transmitters.

Important: Changes or modifications to this product not authorized by AethLabs could void the electromagnetic compatibility (EMC) and wireless compliance and negate your authority to operate the product. This product has demonstrated EMC compliance under conditions that included the use of compliant peripheral devices and shielded cables between system components. It is important that you use compliant peripheral devices and shielded cables between system components to reduce the possibility of causing interference to radios, televisions, and other electronic devices.

2.1.9. Medical Device Interference

The effect of electromagnetic fields from components and radios contained in the microAeth on medical devices is dependent on various factors and is unpredictable. The electromagnetic fields from the instrument may interfere with medical devices.

2.1.10. Explosive Atmospheres

Never use, charge, or make connections to the microAeth in any area with a potentially explosive atmosphere or near fire or flammable substances.

2.1.11. High-consequence Activities

The microAeth is not intended for use where the failure of the microAeth could lead to death, personal injury, or severe environmental damage.

2.1.12. Choking Hazard

Some microAeth components and accessories may present a choking hazard to children. Keep these components and accessories away from children.

2.2. Important Handling Information

2.2.1. Moving Parts

The microAeth contains motorized moving parts. Be careful of moving parts when the filter tape cartridge door is open and or interacting with the filter tape cartridge advance and analysis chamber mechanisms.



2.2.2. Exposure to liquid, excessive dust, or foreign objects

Never expose the microAeth, ports, cables, or connections to the instrument to liquid or excessive dust. Never insert foreign objects into any opening or port. This instrument, ports, and air passageways should not be exposed to rain, moisture, objects filled with liquids, or any other sources or forms of liquid.

2.2.3. Using connectors, ports, and buttons

Never force any connector, cable, or foreign object into any port or opening in the instrument. Do not apply excessive pressure when inserting the filter tape cartridge into the instrument, pressing a button, or inserting or threading a cable or tubing connector into a port. Be careful to align threaded connectors correctly and to assure correct orientation while inserting all connectors. If the cable or tubing connector and port do not join with reasonable ease, they may not be compatible or there may be an obstruction. Always inspect ports and cables before making any connection to the instrument. If a port is obstructed or a cable is damaged or frayed, contact AethLabs or an authorized representative immediately for support and genuine AethLabs replacement components.

2.2.4. Operating Temperature

The microAeth is designed to operate in ambient temperatures and conditions of 0 ~ 40 °C, non-condensing. The microAeth can be damaged and battery life shortened if stored or operated outside of these conditions. For safety reasons the internal battery charger may disable battery charging if the instrument is operating at extreme temperatures. Avoid exposing the microAeth, connections, and tubing to rapid and dramatic changes in temperature or humidity. Care must be taken to identify installation and use conditions that might cause condensation of the sample aerosol stream or of the instrument itself. Such condensation can cause instrument damage, electrical shock, or hazard.

2.2.5. Consumables

Filter tape cartridges will require replacement on a regular basis depending on the measurement environment and the operating settings of the instrument. Only genuine AethLabs filter material and cartridges, supplied by AethLabs or authorized representative, should be used in the microAeth.

2.2.6. Cleaning

If the microAeth is exposed to any liquids or other damaging contaminants, immediately turn off the instrument, disconnect all cables, and remove any foreign substances in contact with the instrument. Do not use liquids or other cleaning products on the instrument. Wait until the microAeth is completely dry before charging or turning on the instrument. Only AethLabs authorized service personnel should clean the air passageways and internal components of the microAeth. Keeping the microAeth and its air passageways, internal components, and optical chambers clean is critical for maintaining the instrument and producing quality measurements. Contamination of the instrument can cause increased measurement noise, poor sealing of the analytical area and degraded operational lifetime of some components. AethLabs recommends sending your instrument for annual service, or more frequent service depending on use and operating conditions.

2.2.7. Replacement Parts

Only genuine AethLabs parts should be used in the microAeth. Only AethLabs authorized service personnel should make repairs, install replacement parts, or open the instrument except for the filter tape cartridge door. Always make sure the filter tape cartridge door is reinstalled when the instrument is in use.

2.2.8. Accessories

Only use genuine accessories from AethLabs or recommended by AethLabs. Do not use any accessories with the microAeth that are not supplied by or recommended by AethLabs, as they may cause damage or hazard.

2.2.9. Servicing

Only AethLabs authorized service personnel should service the microAeth. Never remove covers except for the filter tape cartridge door. Always make sure the filter tape cartridge door is reinstalled when the instrument is in use.

2.2.10. Disposal

The microAeth and/or its battery must be recycled or disposed of properly and separately from general or household waste in compliance with local laws and regulations. When this product reaches its end of life, take it to a collection point designated by local authorities. The separate collection and recycling of your product and/or its battery at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

2.2.11. Shipping

The microAeth MA series instruments contain lithium-ion batteries and therefore must be packaged and shipped properly according to regulations for different shipping methods. Please refer to International Air Transport Association (IATA) regulations when shipping the microAeth as there are limits to how many microAeth can be shipped in a single box based on the battery size in each instrument. The microAeth MA200 contains a 3.6V, 3200mAh (11.52 Wh), 1 cell rechargeable lithium-ion battery. The microAeth MA300 contains a 3.6V, 12800mAh (46.08 Wh), 4 cell rechargeable lithium-ion battery. The microAeth MA350 contains a 3.6V, 12800mAh (46.08 Wh), 4 cell rechargeable lithium-ion battery. Please contact your shipping carrier for more information and for packing instructions.

2.3. Warranty

If product(s) were not purchased directly from AethLabs, please check with your reseller for Warranty details.

Disclaimer of Warranties; Limitation of Liability. Seller warrants that the Products sold hereunder, under normal use and service as described in the operator's manual, shall be free from defects in workmanship and material for the lesser of (i) twelve (12) months, or (ii) the length of time specified in the operator's manual, from the date of the shipment to the Buyer ("Warranty Period"). This Warranty Period is inclusive of any statutory warranty. Notwithstanding the foregoing, this limited warranty is subject to the following exclusions and exceptions: (i) air pumps are warranted only for ninety (90) days unless otherwise specified in the operator's manuals; (ii) parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for the later of (a) ninety (90) days from the date of shipment to the Buyer, or (b) the end of the Warranty Period; (iii) Seller does not provide any warranty on finished goods manufactured by others or on other consumable materials; and (iv) unless specifically authorized by separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller. Seller agrees during the Warranty Period, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with the published specifications thereof; provided that Buyer shall (i) promptly notify Seller in writing upon the discovery of any defect, which notice shall be provided during the Warranty Period and shall include the product model and serial number (if applicable) and details of the warranty claim, and (ii) prepay the shipment costs. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to customer of repaired or replacement Products shall be made in accordance with the delivery provisions set forth in these Terms. In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of: (i) normal wear and tear; (ii) accident, disaster or event of force majeure; (iii) misuse, fault or negligence of or by Buyer; (iv) use of the Products in a manner for which they were not designed; (v) causes external to the Products such as, but not limited to, water damage, impact damage from fall, power failure or electrical power surges, lack of maintenance; (vi) improper storage and handling of the Products; or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by this warranty, Buyer shall pay Seller therefore at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL

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Entire Agreement. This Agreement constitutes the complete agreement between Licensor and you with respect to the subject matter hereof, and supersedes all prior agreements, oral or written, with respect to the subject matter hereof.

2.5. Regulatory and Compliance Notices

This instrument meets the requirements of CE certification.

This device complies with Part 15 of the FCC Rules.

This Class A digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada. If changes are made to this instrument or it is opened without the authorization of the manufacturer, this declaration will be rendered invalid.

Regulatory information, certification, and compliance marks specific to microAeth are available on microAeth and within the microAeth manual.

3. Unpacking

Carefully unpack the instrument and accessories from their packaging. Check to identify that all items are present and that there is no damage. Retain original packaging for safe storage and shipping of the instrument.

3.1. MA200 Included Items

microAeth MA200

MA200 Filter Tape Cartridge (1 installed in instrument)

Barrel jack AC adapter with 1 territory-specific plug

USB communication cable

Serial to USB converter cable

1 meter sampling hose with swivel tube connector

Lapel clip for sampling hose

Cross-platform microAeth® Manager software (for download via AethLabs website)

Manual (for download via AethLabs website)

3.2. MA300 Included Items

microAeth MA300

MA300/350 Filter Tape Cartridge (1 installed in instrument)

Barrel jack AC adapter with 1 territory-specific plug

USB communication cable

Serial to USB converter cable

1 meter sampling hose with swivel tube connector

Lapel clip for sampling hose

Cross-platform microAeth® Manager software (for download via AethLabs website)

Manual (for download via AethLabs website)

3.3. MA350 Included Items

microAeth MA350

MA350/350 Filter Tape Cartridge (1 installed in instrument)

MA350 Sealed connector to DC barrel jack and serial port cable

Barrel jack AC adapter with 1 territory-specific plug

USB communication cable

Serial to USB converter cable

1 meter sampling hose with swivel tube connector

Lapel clip for sampling hose

Cross-platform microAeth® Manager software (for download via AethLabs website)

Manual (for download via AethLabs website)

3.4. Consumables

MA200 Filter Tape Cartridge

The filter tape cartridges are custom designed for use in the microAeth® MA200. The filter tape cartridges have PTFE filter material for collecting a 3 mm sample spot. Cartridges each contain 15 sampling locations.

MA300 / MA350 Filter Tape Cartridge

The filter tape cartridges are custom designed for use in the microAeth® MA300 and MA350. The filter tape cartridges have PTFE filter material for collecting a 3 mm sample spot. Cartridges each contain 85 sampling locations.

3.5. Accessories

microCyclone™ PM2.5 Size-selective inlet

The microCyclone is a miniature PM2.5 size-selective inlet for the microAeth. This sharp-cut cyclone has a size cut of 2.5 micron at 50 ml/min and 1.6 micron at 100 ml/min.

microAeth MA Series Flow Calibration Kit

The microAeth MA Series Flow Calibration Kit comes with all of the components necessary to reliably perform a flow calibration of the microAeth® MA Series instruments. This kit includes a custom designed external mass flowmeter and all necessary tubing, connectors, and cables to perform the simple and fully automated flow calibration. The only way to perform a flow calibration on the MA Series instruments is to use the AethLabs MA Series Flow Calibration Kit.

Portable Aerosol Dryer

A small, portable, passive nafion / dessicant aerosol dryer. Dessicant life of 500 liters before recharge or replacement.

Serial to bare leads cable

This cable allows the microAeth MA Series instruments to send and receive 3.3v TTL serial data from the 4-pin serial port to and from other devices. This cable is not included.

MA350 Sealed connector to bare leads cable

This cable allows the microAeth MA350 to send and receive 3.3v TTL serial data to and from other devices. This cable also allows the MA350 to be powered from an external source. This cable is not included.

3.6. Replacement Parts

microAeth MA Series Flow Calibration Kit Communication cable

This cable allows the microAeth MA Series instruments to communicate with the custom designed external mass flowmeter in the microAeth MA Series Flow Calibration Kit. This cable is included in the microAeth MA Series Flow Calibration Kit.

microAeth MA Series Flow Calibration Kit Inlet filter

This low backpressure inline disc filter is used on the inlet of the external flowmeter of the microAeth MA Series Flow Calibration Kit to keep the external flowmeter clean and to keep the microAeth sampling filter clean during flow calibration. An inline filter isn't required but is recommended especially if a flow calibration is being completed outdoors or in a dirty environment.

Serial to USB converter cable

This cable allows the microAeth MA Series instruments to send and receive serial data from the 4-pin serial port to the USB port of a computer. This cable is also used to upgrade the firmware of microAeth MA Series instruments. This cable is included with all MA Series instruments.

MA350 Sealed connector to DC barrel jack and serial port cable

This cable converts the microAeth MA350 sealed connector port to a DC barrel jack port and a 4-pin serial port. This cable is included with the MA350.

4. Measurements

4.1. Particles

The microAeth MA Series instruments make real-time five wavelength optical analyses by measuring the rate of decrease in transmitted light through the sample filter, due to continuous particle deposition on the filter. Measurement at 880 nm is interpreted as the concentration of Black Carbon ('BC'). Measurement at 375 nm is interpreted as Ultraviolet Particulate Matter ('UVPM') indicative of woodsmoke, tobacco, and or biomass burning. Measurements at 625 nm, 528 nm, and 470 nm wavelengths provide additional information about the aerosol, and allow for the calculation of the angstrom exponent which can be used for source apportionment and other atmospheric investigations.

4.1.1. DualSpot® Loading Compensation (beta)

The microAeth MA Series instruments include hardware and firmware that implement the patented DualSpot® Loading Compensation method. This method simultaneously collects aerosol samples on two analysis spots in parallel and at different face velocities while measuring the rate of change in absorption of transmitted light due to the particles loading on the filter. The use of this method is an optional user selectable feature. **A flow rate of 100 or 150 ml/min is highly recommended when using DualSpot® loading compensation.** Although DualSpot mode can be used in many sampling scenarios, for best results it should be used in stationary applications.

4.2. Temperature

A temperature measurement of the sample air stream is made every Timebase. The sensor value for this measurement is very close to both the filter sampling locations and the internal mass flowmeters. The datastream from this sensor is representative of the internal temperature of the sample air and while it may track changes in external air temperature, it may have a temperature offset compared with actual external ambient air temperature due to internal heating or cooling of the instrument. This sensor value is always recorded. In the data output, this value is recorded in the column labeled "Sample temp (C)." The accuracy of the temperature measurement is typically ± 0.2 °C.

A temperature measurement of the internal chassis of the instrument is made every Timebase. This sensor value is always recorded. In the data output, this value is recorded in the column labeled "Internal temp (C)." The accuracy of the temperature measurement is typically ± 1 °C at 25 °C and typically ± 3 °C over the temperature measurement range of -40 to +85 °C.

4.3. Relative Humidity and Dewpoint

A relative humidity measurement of the sample air stream is made every Timebase. This sensor is coupled to measurement sample spot sense2. In SingleSpot™ mode there is no active flow through the humidity sensor, while in DualSpot® mode there is active flow through the humidity sensor. Therefore the measurement will be more accurate and more responsive in DualSpot® mode. This sensor value is always recorded. In the data output, this value is recorded in the column labeled "Sample RH (%)." The accuracy of the relative humidity measurement is typically ± 1.8 %RH between 10-90 %RH at 25 °C.

A dewpoint calculation is made by the instrument every Timebase. This value is always calculated and recorded using the temperature and relative humidity sensors measurements. In the data output, this value is recorded in the column labeled "Sample dewpoint (C)."

4.4. Altimeter/Barometer

A pressure measurement of the internal chassis of the instrument is made every Timebase. This sensor is always recorded. In the data output, this value is recorded in the column labeled "Internal pressure (Pa)" The accuracy of the absolute pressure measurement is typically ± 0.4 kPa at test conditions of 50 to 110 kPa over -10 °C to 70 °C.

4.5. Accelerometer

A 3-axis acceleration measurement of the internal chassis of the instrument is made every Timebase. This sensor is always recorded. In the data output, this value is recorded in the columns labeled "Accel X," "Accel Y," and "Accel Z."

4.6. GPS

The microAeth has access to the Global Positioning System with a built-in antenna. The GPS is used for precise, automatic time synchronization and for optional location tracking.

4.7. Flow

Two separate mass flowmeters each make flow measurements of the sample air stream and are recorded every Timebase. These sensor measurements are always recorded and represent the average flow through the timebase period (not instantaneous). In the data output, these values are recorded in the column labeled "Flow total (mL/min)" and "Flow1 (mL/min)." The accuracy of the flow measurements is typically $\pm 5\%$ FS 0-1 L/min (25 °C characteristic). The repeatability of the flow measurements is typically $\pm 0.4\%$ FS 0-1 L/min.

When the instrument has DualSpot loading compensation enabled, a flow calculation is made by the instrument every Timebase. This value is always calculated and recorded. In the data output, this value is recorded in the column labeled "Flow2 (mL/min)."

5. Configuration and Operation

5.1. Overview

The microAeth MA Series instruments are highly sensitive, portable, and miniature five-wavelength instruments designed for measuring the light absorbing carbon ('LAC') particles. The instruments have an 880 nm optical channel which is primarily interpreted as Black Carbon ('BC'). The instruments also measure Ultraviolet Particulate Matter ('UVPM') and makes measurements at three other wavelengths which can be used to calculate the angstrom exponent for source apportionment or other investigations into the optical properties of light absorbing particles in the atmosphere. The instruments are based on the well-established Aethalometer® measurement principle used for over 30 years in laboratory-sized analyzers and incorporate the patented DualSpot® loading compensation method. The microAeth draws an air sample at a flow rate of 50, 100, or 150 ml/min through a 3 mm diameter portion of the filter media. Optical transmission through the 'Sensing' spot is illuminated by stabilized 880 nm (IR), 625 nm (Red), 528 nm (Green), 470 nm (Blue), and 375 nm (UV) LED light sources and measured by a detector. The optical attenuation (ATN) due to absorbance of particles collected on the spot is measured relative to an adjacent 'Reference' portion of the filter where no particles are accumulated. This change in ATN is derived using a starting measurement and an additional measurement at the end of the timebase period. The gradual accumulation of optically-absorbing particles leads to an increase in ATN from one period to the next. The air flow rate through the spot is measured by one or more mass flow sensor(s) which are also used to stabilize the pump. The electronics and microprocessor measure and store the data each timebase period to determine the ATN increment during each timebase. This is then converted to a mass concentration of BC expressed in nanograms per cubic meter (ng/m³) using the known optical absorbance per unit mass of Black Carbon material. The instrument's operating parameters are set up by an external software application or by the on-board interface. Operation is completely automatic after the instrument is turned on and sampling is started. During operation, the microprocessor performs the optical measurements, measures and stabilizes the air flow, calculates the BC mass concentration and records data to internal nonvolatile memory. The data may be downloaded at a later time by the same external software package or over serial. The microAeth derives its power from an internal rechargeable lithium-ion battery.

5.2. Recommendations for Best Use Practices

The small size and light weight of the microAeth® allow it to be used to gather data in a wide range of operational scenarios, not always possible using larger instruments. Optimization of performance across the breadth of applications requires an understanding of scientific objectives, operational settings, their impact on instrumental sensitivity and trade-offs, as well as proper maintenance of the instrument. The following recommendations provide general guidelines.

5.2.1. Instrument Settings: Measurement Timebase and Flow Rate

In order to get the best data from the microAeth for a sampling campaign, we highly recommend that the instrument warm up for approximately 30 minutes so that it can equilibrate. The microAeth can acquire data on six timebase settings: 1, 5, 10, 30, 60, or 300 seconds. The 1 second timebase should only be used under special circumstances where a decreased signal-to-noise ratio is acceptable. At this setting, instrumental noise is larger and typically requires post-processing. The microAeth pump can operate at three sampling flow rate settings: 50, 100, and 150 ml/min. The choice of these parameters affects the operation and data. On a 1 second timebase, the instrument will acquire about 25 megabytes of data per day, which may be more challenging to handle and take longer to download. Due to the flow split between

Spot 1 and Spot 2 the measurement sensitivity in DualSpot® mode will be lower than in SingleSpot™ mode for the same total flow rate. DualSpot mode may not be compatible with 50 ml/min flow rate unless measuring higher mass concentrations.

5.2.2. Battery Runtime on Single Charge

Battery Runtime on Single Charge: Affected by flow rate and timebase settings.

NOTE: Battery life will gradually diminish after many cycles (~ 1 year of use). Runtimes vary based on individual microAeth instruments and specific environments.

5.2.3. Effects of Contamination

Effects of Contamination, Vibration, and Impact: Primarily affected by timebase setting.

1 second	5 seconds	10 seconds	30 seconds	60 seconds	300 seconds
very large	large	large	moderate	low	least

5.2.4. Recommended Settings for Different Scenarios

Different Black Carbon measurement scenarios require different operational settings for optimum performance. The 1 second timebase setting is a 'Data Acquisition Mode' intended for subsequent processing, and should NOT be used for routine monitoring. On a 1 second timebase, the instrument will acquire about 25 megabytes of data per day, which may be more challenging to handle and take longer to download. Data collected on a 1 second timebase should always be smoothed or averaged over longer periods, in order to optimize the signal-to-noise ratio at the desired time resolution.

5.2.5. Contamination, Maintenance, and Cleaning of Sample Chamber

If a loose particle of contamination enters the sample chamber of the microAeth or the instrument experiences vibration or impact, the data may be degraded. Shaking or tapping a "dirty" instrument may create data excursions that are far larger than those of a "clean" unit. These effects are amplified greatly at the shorter timebase settings. Our recommendations for cleaning are based upon the likelihood of contamination and the nature of use.

5.2.7. Contamination Probability for Various Use Scenarios

Sampling Scenario without use of microCyclone™	Contamination Probability
Dry, dusty environment	High
Occupational settings with combustion exhaust	High
Exposure to "oily" smokes such as biomass-burning plumes, 2-cycle engine exhaust	High
Presence of suspended fluff, fibers, pollen	High
Immediate vicinity of traffic and roadways	High
Outdoor urban environments	High
Outdoor rural environments (without dust, fluff, pollen)	High
Residential indoor environments	High

5.2.8. Recommended Cleaning & Maintenance Intervals

It is suggested to perform standard maintenance at least once per 12-18 months. Unique, dirtier and or higher concentration sampling environments and applications may require standard maintenance on more regular intervals. It is recommended that users plan standard maintenance schedules that best coincide with and allow for the best data quality during measurement campaigns.

5.2.9. microCyclone™ PM2.5 Size-selective inlet

The microCyclone™ may help to prevent contamination in dusty or dirty environments where larger diameter particles are present. The microCyclone PM2.5 Size-selective inlet can be connected to the inlet of the microAeth to provide a PM2.5 size cut point when the microAeth is set to a 50 ml/min flow rate. A 1.6 micron size cut point is provided by the microCyclone when connected to a microAeth with a 100 ml/min flow rate. The microCyclone may not be appropriate for use with the microAeth MA200, MA300, or MA350 when using specific operating settings depending on flow rates and if DualSpot® loading compensation is enabled. The microCyclone can be used at 100 ml/min with a outpoint of 1.6 micron in DualSpot mode. While operation at 50 ml/min in DualSpot mode may be possible it has not yet been validated.

IMPORTANT: If a microCyclone is being used with your microAeth, please clean it on a frequent basis, depending on sampling environment and concentrations. Please see microCyclone manual and documentation for more information.

5.3. Measurement Sampling Connections

5.3.1. Inlet Port

The inlet port is a 10-32 UNF inch threaded port.

The inlet port and all connections to the inlet port must be properly protected from the environment. There must be limited restriction to flow while protection from water, insects, bugs, and other objects that can block or infiltrate the instrument air pathway. Extra precaution must be taken as the internal pump of the instrument is pulling air into the instrument through this port.

It is always recommended to use the sampling tube assembly supplied with your microAeth, screwed into the instrument's inlet port. Using this sampling tube assembly allows for more targeted sampling, can provide basic protection to the instrument inlet, and prevents the possibility of light leakage into the instrument's sample chamber.

5.3.2. Outlet Port

The outlet port is a 10-32 UNF inch threaded port.

The outlet port and all connections to the outlet port must be properly protected from the environment. There must be limited restriction to flow while protection from water, insects, bugs, and other objects that can block or infiltrate the instrument air pathway.

5.4. Power

5.4.1. Charging

Input: 100~240 VAC 50/60Hz 0.4A, Output: 5VDC / 2A, with option for Type A, C, G, or I plug
It is highly recommended to use the DC barrel jack for charging and power. Power via USB may introduce additional noise to measurement data.

Charging times with instrument turned off:

MA200:

Fast charging DC via barrel jack AC adapter: ~3 hours

USB charging: ~6.5 hours

MA300:

Fast charging DC via barrel jack AC adapter: ~11.75 hours

USB charging: ~25.75 hours

MA350:

Sealed connector for fast charging DC via barrel jack AC adapter: ~11.75 hours

USB charging on inside panel: ~25.75 hours

5.4.2. Turn on

The on-board user interface on the front of the microAeth can be used to turn on the instrument.

1) To turn on the microAeth, press and hold only one of the three buttons for 2 seconds. The screen and instrument will turn on and the instrument serial number will be displayed.

5.4.3. Turn off

The on-board user interface on the front of the microAeth can be used to turn off the instrument.

1) Use the left and right buttons to scroll through the top level menu options to 'Turn Off'.
2) Press the center button to select the 'Turn Off' option. The screen and instrument will turn off.

5.5. Communication

5.5.1. On-board user interface

The microAeth has an on-board user interface with a backlit low power screen and three buttons.

5.5.2. USB 2.0

The microAeth has a USB 2.0 full speed port for communication with the cross-platform microAeth® Manager software for configuring the instrument settings and downloading data.

The AethLabs provided mini-B to Type A USB cable can provide communication and power to and from the device, although it is not recommended for providing power to the microAeth while making measurements. A USB connection to a computer running the microAeth Manager software can be used to communicate with the device. Charging through the USB port is at a slower rate than the barrel jack AC adapter. It is highly recommended to use the DC barrel jack for charging and power while making measurements.

5.5.3. 3.3V TTL Serial

The microAeth has a 4-pin serial port for communication through 3.3V TTL serial with external data acquisition systems or for direct integration into another system.

Communication through the 3.3V TTL serial port can be established to a computer through a terminal emulator using the custom AethLabs 4-pin Serial to USB converter cable. **AethLabs only supports Tera Term for Windows.** The default terminal emulator settings and terminal emulator settings required for updating firmware in the bootloader are as follows:

Baud Rate	Data	Parity	Stop	Flow control
1000000	8 bit	none	1 bit	none (Xon/Xoff for firmware update)

NOTE: The serial baud rate can be changed using the on-board LCD interface and the Change Serial Baud menu or using the microAeth Manager and the Baud rate setting under Serial and Communications. When installing firmware using the instrument bootloader, the baud rate is always 1000000 even if the baud rate setting has been changed.

Before using the AethLabs 4-pin Serial to USB converter cable, it may be required to install drivers from Future Technology Devices International Ltd. (FTDI) in order for the converter cable to be recognized by and used with the computer.

A bare leads serial cable is available from AethLabs for custom integration work.

CAUTION: Interfacing to the serial port for customization and integration requires care, a short of the power supply or improper grounding practices could cause additional instrument noise and / or in the case of a short circuit or over-voltage / over-current, damage to the instrument.

5.5.4. Wi-Fi

The microAeth has 802.11b Wi-Fi with AES hardware encryption built-in.

5.5.5. Bluetooth Low Energy

The microAeth has Bluetooth Low Energy built-in.

5.6. Instrument Operating Parameters

5.6.1. Date/Time: GPS time synchronization (microAeth Manager only)

The time on the microAeth can be automatically synchronized to satellites using its on-board GPS unit. Time synchronization will automatically occur even if the GPS setting is turned off and location is not being recorded. Time is ISO 8601 formatted.

It is very important to confirm the date and time of the microAeth before a sampling campaign.

5.6.1. Date/Time: Application time synchronization (microAeth Manager only)

The time on the microAeth can be manually synchronized to the time on the computer. Time synchronization will occur between the microAeth and the computer when the button is clicked in the microAeth Manager. Time is ISO 8601 formatted.

It is very important to confirm the date and time of the microAeth before a sampling campaign.

5.6.2. Date/Time: Timezone offset (microAeth Manager only)

The timezone offset setting permits the user to select a timezone offset from Coordinated Universal Time (UTC) to be used as part of the ISO 8601 time and date format in the instrument and recorded with instrument measurement data. Daylight savings time offsets are not automatically adjusted by the instrument or the microAeth Manager.

5.6.3. Flow setpoint

The sampling flow setpoint setting permits the user to select a sampling flow rate setpoint of 50, 75, 100, 125 or 150 ml/min. **A flow rate of 100, 125 or 150 ml/min is highly recommended when using DualSpot® loading compensation.** It is recommended to use lower flow rates in areas with high BC concentrations, and higher flow rates when maximum sensitivity is required in areas of low BC concentrations. A lower flow rate should also be selected for longer run times and extended battery life. Please read section 5.2 Recommendations for Best Use Practices for more information.

5.6.4. Timebase

The timebase setting permits the user to select a measurement integrating time of 1, 5, 10, 30, 60, or 300 second(s). The date and time (timestamp) is recorded at the end of the sampling and measurement interval.

It is recommended to use a 30 or 60 second timebase for most 'human exposure' or 'ambient monitoring' measurements. Faster timebases will result in higher noise, and are most useful either for direct source monitoring (tailpipe analysis) or for other applications requiring extremely rapid data. A 300 second timebase can be selected for longer run times and extended battery life. Please read section 5.2 Recommendations for Best Use Practices for more information.

5.6.5. Wavelengths (microAeth Manager only)

The wavelengths setting permits the user to select the measurement wavelength(s) used for particle measurements.

1 Wavelength: IR (880 nm)

2 Wavelengths: IR (880 nm), UV (375 nm)

5 Wavelengths: IR (880 nm), Red (625 nm), Green (528 nm), Blue (470 nm), UV (375 nm)

5.6.6. Sampling mode (microAeth Manager only)

The sampling mode setting permits the user to select if the microAeth is in SingleSpot™ or DualSpot® loading compensation sampling mode. **A flow rate of 100, 125 or 150 ml/min is highly recommended when using DualSpot® loading compensation.** Although DualSpot mode can be used in many sampling scenarios, for best results it should be used in stationary applications.

5.6.7. AutoSample

The AutoSample setting permits the user to select if the microAeth will automatically start sampling and measurements.

Off: Automatic start of sampling and measurements will not occur.

Resume after power loss (Resume): If the instrument was previously sampling and experienced a power failure. If this setting is on, the instrument will automatically start sampling and measurements when it turns on from a loss of power or some other event that caused the instrument to turn off.

External power control (Ext Power): If the 5V barrel jack of the instrument is supplied with power, the instrument will automatically turn on and start sampling and measurements. If power is removed from the 5V barrel jack of the instrument, the instrument will automatically stop sampling and measurements and turn off.

5.6.8. GPS (microAeth Manager only)

The GPS setting permits the user to select if GPS location recording is turned on or off.

5.6.9. Serial baud rate

The serial baud rate setting permits the user to select the serial baud rate of 57600, 115200, 230400, 460800, 921600, or 1000000 to use when measurement data is transmitted through the serial port.

NOTE: When installing firmware using the instrument bootloader, the baud rate is always 1000000 even if the baud rate setting has been changed.

5.6.10. Serial data mode

The serial data mode setting permits users to select the serial data mode of the serial port. The following three options are available:

Off: No measurement data will be transmitted via the serial port. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

Streaming: Measurement data will be transmitted via the serial port while sampling and measurements are occurring. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

Polled: Measurement data and instrument status can be polled and the operating controls of the instrument can be controlled using the command line interface (CLI) via the serial port. See section 5.9. Command Line Interface (CLI) for Polled Serial Data Mode for CLI commands. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

5.6.11. Serial data format (microAeth Manager only)

The serial data format setting permits the user to select the serial data format of the serial port of measurement data in streaming and polled serial data modes. Two format options are available: Verbose and Minimal. For more information about serial output formatting structures, see section 6.2. Serial Output Format Structures.

5.6.12. Tape advance ATN threshold

The tape advance ATN threshold setting permits the user to enter the attenuation (ATN) threshold natural number value of 1 to 100 that will trigger an automatic tape advance to a new filter sampling location during a sampling and measurement period. The attenuation (ATN) threshold value will trigger a tape advance when the first of the wavelength measurements reaches this threshold.

NOTE: The lowest wavelength light source enabled will typically trigger the attenuation (ATN) tape advance.

5.7. Using the microAeth Manager Software

5.7.1. microAeth Manager Software Installation

The microAeth Manager for macOS® and Windows® is available for download from the AethLabs website at <https://aethlabs.com/microaeth/software>. Before installation, check with the computer's system administrator to make sure that the correct permissions have been granted on the computer to install and run a new application. Please visit the AethLabs website for more information and to sign up for software announcements and to receive notifications of software and firmware updates.

Before installing or upgrading microAeth Manager, make sure to export and backup all data stored in the microAeth Manager local database.

5.7.1.1. Installation on macOS

- 1) Delete any previous versions of the microAeth Manager from the computer.
- 2) Download the microAeth Manager software to the computer running macOS®.
- 3) Locate and open the file 'microAeth_Manager_x.xx.dmg' on the computer.
- 4) The virtual disk image will be mounted and a window will open showing the 'microAeth Manager' application file.
- 5) Drag the 'microAeth Manager' application file to the 'Applications' folder of the computer. The application is now installed and ready for use with the microAeth MA series instruments.
- 6) When the microAeth Manager is first opened after installation on the computer, a prompt may appear with the following message and verification request, "microAeth Manager" is an application downloaded from the Internet. Are you sure you want to open it?' Please confirm to start using the application.

5.7.1.2. Installation on Windows

- 1) Delete any previous versions of the microAeth Manager from the computer.
- 2) Download the microAeth Manager software to the computer running Windows®.
- 3) Locate and open the file 'microAeth_Manager_x.xx.exe' on the computer.
- 4) A prompt may appear with the following message and verification request, 'Do you want to allow this app from an unknown publisher to make changes to your device?' Please confirm to start the installation wizard.
- 5) The microAeth Manager installation wizard will guide the user through the process of choosing the application installation location, creating a desktop shortcut icon, and opening the Device Driver Installation Wizard for installing USB drivers required for the computer to communicate with the microAeth MA series instruments.
- 6) A prompt may appear with a message and verification request to install the USB device software or drivers required. Please confirm and complete both installation wizards.
- 7) The application is now installed and ready for use with the microAeth MA series instruments.

5.7.2. Overview

The microAeth Manager software is designed for use with microAeth MA series instruments only. The microAeth Manager is intended to help with the configuration and management of the microAeth MA series instruments and their collected data. Only one microAeth can be connected to the computer and microAeth Manager software at a time. Plug in the USB cable to the USB port of the microAeth. Plug in the USB A connector of the cable into a computer where the microAeth Manager is installed. Turn on the microAeth MA series instrument and open the microAeth Manager. The instrument serial number and name will appear in the microAeth Manager device section of the main application window and then the instrument can be configured and its data can be downloaded and managed through the application.

5.7.2.1. Main Application Window

The microAeth Manager main application window consists of three sections: Manage, Notifications, and Device Section.

5.7.2.1.1. Manage Application Button and Section

Clicking the 'Manage application' button in the top right of the main application window will toggle open and close the Manage application section where the user can manage general settings and find out more information about the application.

The 'Info' button and the application version are in the top right of the 'Application settings' section. If the 'Info' button is clicked, a window will appear with more detailed information about the application, legal notices, a link for checking for available microAeth Manager updates, and a link to the AethLabs website. **To check if updates of the microAeth Manager are available, click the 'Check for updates' button.** A web browser will open and take you to the AethLabs website for more information about the latest version available of the microAeth Manager.

The 'Show 24 hour format' toggle in the 'Application settings' section can be used to change the time formatting in the application.

The 'Clear database' button in the 'Local database' section in the top right allows the user to delete all data previously downloaded from microAeth MA series instruments and currently stored in the microAeth Manager application local database. If the 'Clear database' button is clicked, a window will appear to confirm if the user would like to delete all data in the application database. The user must confirm by typing in 'DELETE' and clicking the 'Delete all data in the application database' button. **ONCE THIS ACTION IS COMPLETED, IT IS NOT REVERSIBLE. Clearing and deleting the data in microAeth Manager local database does not delete data stored on a microAeth MA series instrument. It only deletes the data that was previously downloaded and stored in the microAeth Manager local database on that specific computer.** AethLabs recommends regularly deleting the data in the microAeth Manager local database as the time it takes to access the microAeth Manager local data base through the 'Manage data' button will increase as the data base size increases.

5.7.2.1.2. Notifications Section

The notifications section displays notifications in the expandable and collapsible log. Clicking the 'View all notifications' button on the right of the main application window will toggle open the notifications log. Clicking the same button labeled 'Collapse notifications' will collapse the notifications log to display the single latest notification.

5.7.2.1.3. Device Section

The device section displays the interface for configuring settings, downloading data, and managing data from microAeth MA series instruments. This area will display 'Looking for connected devices' and a searching animation when no microAeth MA series instruments are connected and or communicating with the microAeth Manager.

When a microAeth MA series instrument is connected and communicating with the microAeth Manager, the section 'Local devices' and the instrument device pane for the specific connected microAeth MA series instrument will appear below.

The name and serial number of the instrument are displayed in the top left of the instrument device pane title bar. The name of the instrument can be edited by clicking on the name of the instrument in the device pane title bar.

The USB icon and device pane toggle button are displayed in the top right of the instrument device pane title bar. The USB icon will display green when the instrument is connected with the microAeth Manager. The device pane toggle button with the vertical arrow in it, located in the far right of the instrument device pane title bar, is used to expand and collapse the device pane. The device pane displays status, settings, and data information for the connected instrument.

5.7.3. Configuration and Status of Instrument and Operating Parameters

The microAeth Manager software can be used to only configure microAeth MA series instruments when the microAeth is connected to the computer. Only one microAeth can be connected to the computer and microAeth Manager software at a time. Plug in the USB cable to the USB port of the microAeth. Plug in the USB A plug of the cable into a computer where the microAeth Manager is installed. Turn on the microAeth MA series instrument and open the microAeth Manager. The instrument serial number and name will appear in the microAeth Manager device section of the main application window and then the instrument can be configured through the microAeth Manager device pane.

5.7.3.1. Battery

The microAeth Manager displays the percentage of battery remaining in the microAeth.

5.7.3.2. Status

The microAeth Manager displays the current status of the microAeth.

5.7.3.3. Date/Time

The microAeth Manager displays the current date, time, and timezone offset of the microAeth. Click the 'Time options' button to show the 'Change time options' window to modify date and time settings.

5.7.3.3.1. GPS time synchronization

The GPS time synchronization toggle switch in the 'Change time options' window of the microAeth Manager (click the 'Time options' button on the main application window), can be used to turn GPS time synchronization on or off.

5.7.3.3.2. Application time synchronization

The application time synchronization 'Sync now' button in the 'Change time options' window of the microAeth Manager (click the 'Time options' button on the main application window), can be used to manually synchronize the time of the microAeth and the computer. When time is synchronized, a confirmation notification will be displayed below the button in this window.

5.7.3.3.3. Timezone offset

The timezone offset dropdown and 'Set timezone offset' button in the 'Change time options' window of the microAeth Manager (click the 'Time options' button on the main application window), can be used to select and set a timezone offset from Coordinated Universal Time (UTC) to be used as part of the ISO 8601 time and date format in the instrument and recorded with instrument measurement data. Daylight savings time offsets are not automatically adjusted by the instrument or the microAeth Manager. Select the desired value from the dropdown and click the button 'Set timezone offset' to save. When the timezone offset is saved, a confirmation notification will be displayed below the button in this window.

5.7.3.3.4. Memory

The microAeth Manager displays the percentage of memory available in the microAeth. The microAeth has 16GB of memory which can store 31,250,000 data lines.

- 1 second timebase: 361 days of data
- 5 second timebase: 4.95 years of data
- 10 second timebase: 9.90 years of data
- 30 second timebase: 29.72 years of data
- 60 second timebase: 59.45 years of data
- 300 second timebase: 297.27 years of data

AethLabs recommends regularly deleting data on the microAeth as all unsynchronized data is downloaded together from the microAeth to the microAeth Manager local database on each different computer.

5.7.3.3.5. Firmware

The microAeth Manager displays the operating system firmware version running on the microAeth.

5.7.3.3.6. Flow setpoint

The flow setpoint dropdown can be used to select a sampling flow setpoint of 50, 75, 100, 125 or 150 ml/min. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel. **A flow rate of 100, 125 or 150 ml/min is highly recommended when using DualSpot® loading compensation.**

5.7.3.3.7. Timebase

The timebase dropdown can be used to select the measurement integrating time of 1, 5, 10, 30, 60, or 300 second(s). Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

5.7.3.3.8. Wavelengths

The wavelengths dropdown can be used to select the measurement wavelength(s) used for particle measurements. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

- 1 Wavelength: IR (880 nm)
- 2 Wavelengths: IR (880 nm), UV (375 nm)
- 5 Wavelengths: IR (880 nm), Red (625 nm), Green (528 nm), Blue (470 nm), UV (375 nm)

5.7.3.3.9. Sampling mode

The sampling mode dropdown can be used to select if the instrument is in SingleSpot™ or DualSpot® loading compensation sampling mode. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel. **A flow rate of 100 or 150 ml/min is highly recommended when using DualSpot® loading compensation.** Although DualSpot mode can be used in many sampling scenarios, for best results it should be used in stationary applications.

5.7.3.3.10. AutoSample

The AutoSample dropdown can be used to select the autosample mode. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

Off: Automatic start of sampling and measurements will not occur.

Resume after power loss (Resume): If the instrument was previously sampling and experienced a power failure. If this setting is on, the instrument will automatically start sampling and measurements when it turns on from a loss of power or some other event that caused the instrument to turn off.

External power control (Ext Power): If the 5V barrel jack of the instrument is supplied with power, the instrument will automatically turn on and start sampling and measurements. If power is removed from the 5V barrel jack of the instrument, the instrument will automatically stop sampling and measurements and turn off.

5.7.3.3.11. GPS

The GPS toggle switch can be used to turn GPS recording on or off.

5.7.3.3.12. Serial baud rate

The serial baud rate dropdown can be used to select the serial baud rate for all data transmitted through the serial port. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

NOTE: When installing firmware using the instrument bootloader, the baud rate is always 1000000 even if the baud rate setting has been changed.

5.7.3.13. Serial data mode

The serial data mode dropdown can be used to select the serial mode of the serial port. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

Off: No measurement data will be transmitted via the serial port. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

Streaming: Measurement data will be transmitted via the serial port while sampling and measurements are occurring. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

Polled: Measurement data and instrument status can be polled and the operating controls of the instrument can be controlled using the command line interface (CLI) via the serial port. See section 5.9. Command Line Interface (CLI) for Polled Serial Data Mode for CLI commands. On-board user interface data and the output of Display All Settings and Display FlowCal Info will still be transmitted when selected and at startup.

5.7.3.14. Serial data format

The serial data format dropdown can be used to select the serial data format when serial data streaming is turned on. Select the desired value from the dropdown and click the checkmark to save and the 'x' to cancel.

For more information about serial output formatting structures, see section 6.2. Serial Output Format Structures.

5.7.3.15. Tape advance ATN threshold

The tape advance ATN threshold field can be used to enter the attenuation (ATN) threshold natural number value of 1 to 100 that will trigger an automatic tape advance to a new filter sampling location during a sampling and measurement period. The attenuation (ATN) threshold value will trigger a tape advance when the first of the wavelength measurements reaches this threshold. Enter the desired value into the field and click the checkmark to save and the 'x' to cancel.

NOTE: The lowest wavelength light source enabled will typically trigger the attenuation (ATN) tape advance.

5.7.4. Data Sessions Management in the microAeth Manager

Management of data both stored on the microAeth and data stored in the microAeth Manager local database can be completed through the Manage data window of the microAeth Manager. Data is downloaded from the instrument via the USB port and is stored in the microAeth Manager local database.

The downloaded data is divided into data sessions in the microAeth Manager local database based on previous sampling and measurements completed with the instrument. A data session is created when the instrument starts sampling and measurements and the data session is closed when the instrument sampling and measurements are stopped. The downloaded data sessions can then be exported to one .csv file per session using the 'Data sessions in application' section of the Manage data window. Individual or multiple data sessions can be selected and exported. When exporting long data sessions that span multiple calendar days, the user can select to have the exported data session files split into multiple files based on the calendar days of that session.

Data session files are exported to a folder named with the instrument serial number (MAxxx-xxxx) in the

directory shown at the bottom of the Manage data window below the 'Export selected sessions' button and to the right of the text 'Data file export location:' The data file export directory is located in the computer operating system user directory '/Documents/AethLabs_microAeth_Manager_Data'.

Session data files are exported as .csv files with the following naming system:

MAxxx-xxxx_Szzzz_yymmddhhmmss

xxx-xxxx is the serial number of the instrument

zzzz is the session ID number

yymmddhhmmss is the year, month, day, hour, minute, and second of when the session started

Session data files that are split into multiple files based on the calendar days of that session are exported as .csv files with the following naming system:

MAxxx-xxxx_Szzzz_Pv_yymmddhhmmss

xxx-xxxx is the serial number of the instrument

zzzz is the session ID number

v is the split session partial file number

yymmddhhmmss is the year, month, day, hour, minute, and second of when the split session partial file started within the session

5.7.5. Data Download in the microAeth Manager

The microAeth Manager can be used to download data stored on the instrument via the USB port. Data can be downloaded to the local database in the client application software using the USB cable provided by AethLabs. Once the data stored on the microAeth is downloaded to the local microAeth Manager database on the computer, the data can then be exported to .csv files. There are two locations in the microAeth Manager to download data from a microAeth.

Option 1:

- 1) Plug in the USB cable to the USB port of the microAeth. Plug in the USB A plug of the cable into a computer where the microAeth Manager is installed and where data will be downloaded.
- 2) Open microAeth Manager.
- 3) Turn on the microAeth.
- 4) The microAeth information will be loaded into the microAeth Manager instrument device pane.
- 5) If there is new data stored on the microAeth that has not been downloaded to the microAeth Manager local database, then the text 'There are xxxx points of new data available to download' and a 'Download now' button will appear below the instrument device pane title bar where the name and serial number of the instrument are displayed.
- 6) To download data from the instrument to the microAeth Manager local database, click the 'Download now' button.
- 7) A window will appear with the title 'Downloading data progress for MAxxx-xxxx' and the 'Current Progress: xx%' progress bar.
- 8) When the download is complete, the progress bar will change to 'Data download is complete (xxxx points)' and the 'Close' button can be clicked to return to the main application window.

Option 2:

- 1) Plug in the USB cable to the USB port of the microAeth. Plug in the USB A plug of the cable into a computer where the microAeth Manager is installed and where data will be downloaded.
- 2) Open microAeth Manager.
- 3) Turn on the microAeth.
- 4) The microAeth information will be loaded into the microAeth Manager instrument device pane.
- 5) If there is new data stored on the microAeth that has not been downloaded to the microAeth Manager local database, then the text 'There are xxxx points of new data available to download' and a 'Download now' button will appear below the instrument device pane title bar where the name and serial number of the instrument are displayed.
- 6) Click the 'Manage data' button to open the 'Manage data for MAxxx-xxxx' window.
- 7) At the top of this window is the 'Data on device' section to manage the data for this microAeth that is stored on the instrument. At the bottom of this window is the 'Data sessions in application local database' section where previously downloaded data sessions from the instrument that are stored in microAeth Manager local database are displayed.
- 7) If there is new data stored on the microAeth that has not been downloaded to the microAeth Manager local database, then in the 'Data on device' section at the top of the 'Manage data for MAxxx-xxxx' window, the 'Download data from device (xxxx points)' button will appear.
- 8) To download data from the instrument to the microAeth Manager local database, click the 'Download data from device (xxxx points)' button.
- 7) A window will appear with the title 'Downloading data progress for MAxxx-xxxx' and the 'Current Progress: xx%' progress bar.
- 8) When the download is complete, the progress bar will change to 'Data download is complete (xxxx points)' and the 'Close' button can be clicked to return to the main application window.

5.7.6. Exporting Data from the microAeth Manager local database

Once the data stored on the microAeth is downloaded to the local microAeth Manager database on the computer, the data can then be exported to .csv files.

- 1) Plug in the USB cable to the USB port of the microAeth. Plug in the USB A plug of the cable into a computer where the microAeth Manager is installed and where data will be downloaded.
- 2) Open microAeth Manager.
- 3) Turn on the microAeth.
- 4) The microAeth information will be loaded into the microAeth Manager instrument device pane.
- 5) Click the 'Manage data' button to open the 'Manage data for MAxxx-xxxx' window. A new window will open that shows all data files that were downloaded from the microAeth and are currently stored in the local microAeth Manager database on the computer.
- 6) At the top of this window is the 'Data on device' section to manage the data for this microAeth that is stored on the instrument. At the bottom of this window is the 'Data sessions in application local database' section where previously downloaded data sessions from the instrument that are stored in microAeth Manager local database are displayed.
- 7) Select the checkboxes of all data sessions to be export to .csv files.
- 8) The 'Split sessions into calendar days on export' toggle switch can be used to split exported data sessions that span multiple calendar days into multiple files based on the calendar days of that session.
- 9) To export the selected data sessions, click the 'Export selected sessions' button at the bottom of the window.
- 10) Data session files are exported to the to a folder named with the instrument serial number (MAxxx-xxxx)

in the directory shown at the bottom of the Manage data window below the 'Export selected sessions' button and to the right of the text 'Data file export location:' The data file export directory is located in the computer operating system user directory '/Documents/AethLabs_microAeth_Manager_Data'.

For more information about data file naming, see section 5.7.4. Data Sessions Management in the microAeth Manager.

For more information about data file structures, see section 6.1. Data File Structure.

5.7.7. Delete All Data on the microAeth

ONCE THIS ACTION IS COMPLETED, IT IS NOT REVERSIBLE. Deleting the data on the microAeth deletes all data stored on a microAeth.

- 1) Plug in the USB cable to the USB port of the microAeth. Plug in the USB A plug of the cable into a computer where the microAeth Manager is installed.
- 2) Open microAeth Manager.
- 3) Turn on the microAeth.
- 4) The microAeth information will be loaded into the microAeth Manager instrument device pane.
- 5) Click the 'Manage data' button to open the 'Manage data for MAxxx-xxxx' window. A new window will open that shows all data files that were downloaded from the microAeth and are currently stored in the local microAeth Manager database on the computer.
- 6) At the top of this window is the 'Data on device' section to manage the data for this microAeth that is stored on the instrument. At the bottom of this window is the 'Data sessions in application local database' section where previously downloaded data sessions from the instrument that are stored in microAeth Manager local database are displayed.
- 7) In the 'Data on device' section, click the 'Delete all data on device button'.
- 8) The 'Confirm deleting data' window will open. Type 'DELETE' into the text field.
- 9) **ONCE THIS ACTION IS COMPLETED, IT IS NOT REVERSIBLE.** Press the 'Delete all on the device' button to confirm.
- 10) All data on the microAeth is now erased.
- 11) Unplug the USB cable and once the microAeth information is unloaded from the microAeth Manager instrument device pane, plug the USB cable back in.

5.8. Using the on-board user interface

5.8.1. Overview

The on-board user interface of the microAeth MA Series instruments consists of a backlight screen and three buttons. This interface can be used to configure specific settings and operate the instrument.

5.8.2. Configuration of Instrument Operating Parameters

5.8.2.1. Change Timebase

The on-board user interface on the front of the microAeth can be used to change the measurement timebase setting of the instrument.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change Timebase' option.
- 2) Press the center button to select the 'Change Timebase' option and to enter the change timebase submenu.
- 3) Use the left or right buttons to scroll through timebase value options of 1, 5, 10, 30, 60, or 300 second(s).
- 4) Press the center button, 'OK' to select the current timebase value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.2.2. Change Flow

The on-board user interface on the front of the microAeth can be used to change the sampling flow setpoint setting of the instrument.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change Flow' option.
- 2) Press the center button to select the 'Change Flow' option and to enter the change flow submenu.
- 3) Use the left or right buttons to scroll through flow value options of 0, 50, 100, or 150 ml/min.
- 4) Press the center button, 'OK' to select the current flow value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.2.3. Change Tape Adv. ATN

The on-board user interface on the front of the microAeth can be used to change the attenuation (ATN) threshold natural number value of 1 to 100 that will trigger an automatic tape advance to a new filter sampling location during a sampling and measurement period. The attenuation (ATN) threshold value will trigger a tape advance when the first of the wavelength measurements reaches this threshold.

NOTE: The lowest wavelength light source enabled will typically trigger the attenuation (ATN) tape advance.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change Tape Adv. ATN' option.
- 2) Press the center button to select the 'Change Tape Adv. ATN' option and to enter the change submenu.
- 3) Use the left or right buttons to scroll through attenuation (ATN) threshold trigger values of 1 to 100 in increments of 1.
- 4) Press the center button, 'OK' to select the current attenuation (ATN) threshold trigger value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.3. Operation and Status

Before starting measurements, it is recommended that the user verify all parameter settings. A description of each operating parameter and its configuration is described in section 5.6. Instrument Operating Parameters. Instrument settings can be viewed through the microAeth Manager software, or through the serial terminal emulator interface using the Display All Settings menu. **IMPORTANT: When a new sampling and measurement session is started, the microAeth will automatically advance the filter tape cartridge to a new sampling location. If a filter tape cartridge is not installed or is not installed correctly, sampling and measurement will not start.**

5.8.3.1. Start Measurement

The on-board user interface on the front of the microAeth is used to start sampling and measurements using the latest saved settings.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Start Measurement' option.
- 2) Press the center button to select the 'Start Measurement' option. The microAeth screen will display 'SAMPLER PREPARING'. The microAeth will automatically advance the filter tape cartridge to a new sampling location and run its start up routine. When sampling and measurement begins, the screen will display 'SAMPLING' and 'Press Center to Stop'.

To skip the automatic tape advance when starting measurements, in step 2 press and hold the center button for 6 seconds. While holding the center button, the microAeth screen will display 'SAMPLER PREPARING'. Once 'Skipped Tape Advance' flashes on the screen, the center button can be released. When sampling and measurements begin, the screen will display 'SAMPLING' and 'Press Center to Stop'.

NOT RECOMMENDED!

SKIPPING THE AUTOMATIC TAPE ADVANCE AT THE BEGINNING OF SAMPLING AND MEASUREMENTS SHOULD ONLY BE USED WHEN GOOD DATA QUALITY IS NOT NEEDED.

When the automatic tape advance is skipped, a status code is added to each data line that is collected during the sampling period where the automatic tape advance was skipped.

5.8.3.2. Stop Measurement

The on-board user interface on the front of the microAeth is used to stop sampling and measurements.

- 1) While the microAeth is sampling, the screen will display 'SAMPLING' and 'Press Center to Stop'.
- 2) Press and hold the center button for 2 seconds to stop sampling and measurement. 'STOPPED' will be displayed on the screen and sampling and measurement will finish.

5.8.3.3. Advance Tape

The on-board user interface on the front of the microAeth can be used to manually advance the filter tape.

IMPORTANT: Manually advance the filter tape before a flow calibration or optical calibration to ensure minimal loading of the sample spots.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Advance Tape' option.
- 2) Press the center button to select the 'Advance Tape' option. The microAeth will advance the filter tape cartridge to a new sampling location. The screen will display '-Releasing Tape' then '-Advancing Tape' and then '-Clamping Tape' during the tape advance process.

5.8.3.4. Filter Tape Cartridge Removal and Installation

The on-board user interface on the front of the microAeth is used to remove and install the filter tape cartridge.

- 1) Make sure that the microAeth is not sampling. If the instrument is sampling, use the on-board interface to stop sampling and measurements.
- 2) Unscrew the large flat head slotted screw(s) in the filter tape cartridge door of the case. When the screw is completely free of its mating threaded hole, use the flat head slotted screw(s) to pull the filter tape cartridge door from the case.
- 3) The filter tape cartridge will now be exposed or if a filter tape cartridge is not currently installed, the cartridge holder area will be empty.
- 4) Use the left and right buttons of the on-board user interface to scroll through the top level menu options to 'Release Tape'.
- 5) Press the center button to select the 'Release Tape' option. '-Releasing Tape' will be displayed on the screen and the optical head of the instrument will move to its open position and stop in about 6 seconds.
- 6) Once the optical head stops moving, use the pull tab in the center of the filter tape cartridge to remove the cartridge straight out of the instrument.
- 7) Insert a new filter tape cartridge straight into the instrument, aligning the left and right holes in the cartridge with the two white capstans in the instrument.
- 8) Make sure that the new filter tape cartridge is fully inserted and sits flat in the instrument.
- 9) Use the left and right buttons of the on-board user interface to scroll through the top level menu options to 'Clamp Tape'.
- 10) Press the center button to select the 'Clamp Tape' option. '-Clamping Tape' will be displayed on the screen and the optical head of the instrument will move to its clamped position and stop in about 6 seconds.
- 11) Confirm that the filter tape cartridge is clamped by the optical head.
- 12) If the filter tape cartridge is correctly installed, replace the filter tape cartridge door to its closed position and completely screw the large flat head slotted screw(s) in place. Once the door is in its closed and locked position, the instrument is ready for further use
- 13) If the filter tape cartridge is not fully installed or seated properly in the instrument after clamping the tape, use the left and right buttons to scroll through the top level menu options to 'Release Tape'. Press the center button to select the 'Release Tape' option. If the instrument does not accept the release tape command, press and hold down the center button until the optical head moves up enough to remove the filter tape cartridge. Then remove the filter tape cartridge. Use the left and right buttons to scroll through the top level menu options to 'Clamp Tape'. Press the center button to select the 'Clamp Tape' option. The optical head of the instrument will move to its clamped position and stop, resetting the optical head position. Go to step 4 and try again to replace the filter tape cartridge.

5.8.3.5. Calibrate Flow

IMPORTANT: Please read section 7.3. Flow Calibration and section 7.3.5. Flow Calibration Procedure before using this menu option. The only way to perform a flow calibration on the MA200, MA300, and MA350 is to use a microAeth MA Series Flow Calibration Kit provided by AethLabs. Before starting the automatic flow calibration process, the filter tape cartridge must be at a new clean filter sampling location. The microAeth should be plugged into an external power source. The only way to perform a flow calibration on the MA200, MA300, and MA350 is to use a microAeth MA Series Flow Calibration Kit provided by AethLabs.

5.8.3.6. Test Flow

IMPORTANT: Please read section 7.3.3. Test Flow Procedure before using this menu option. This menu allows the user to change flow setpoint target to 50, 75, 100, 125, or 150 ml/min and to have the measured flow of the internal flowmeter displayed as a comparison to check the quality of the current FlowCal table calibration of the instrument.

5.8.3.7. Calibrate Optics

IMPORTANT: Please read section 7.4. Optical Calibration Procedure before using this menu option. Before starting the automatic optical calibration process, the filter tape cartridge must be at a new clean filter sampling location. The microAeth should be plugged into an external power source. **The optical calibration should be run only when the filter tape cartridge door is installed and closed. The optical calibration CANNOT be cancelled once it is started.**

5.8.3.8. Change Serial Mode

The on-board user interface on the front of the microAeth can be used to change the serial mode setting of the instrument.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change Serial Mode' option.
- 2) Press the center button to select the 'Change Serial Mode' option and to enter the change serial mode submenu.
- 3) Use the left or right buttons to scroll through serial mode value options of Off, Streaming, or Polled.
- 4) Press the center button, 'OK' to select the current serial mode value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.3.9. Change Serial Baud

The on-board user interface on the front of the microAeth can be used to change the serial baud rate setting of the instrument serial port.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change Serial Baud' option.
- 2) Press the center button to select the 'Change Serial Baud' option and to enter the change serial baud submenu.
- 3) Use the left or right buttons to scroll through serial baud value options of 57600, 115200, 230400, 460800, 921600, or 1000000.
- 4) Press the center button, 'OK' to select the current serial baud value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.3.10. Change AutoSample

The on-board user interface on the front of the microAeth can be used to change the autoSample setting of the instrument.

- 1) Use the left and right buttons to scroll through the top level menu options to the 'Change AutoSample' option.
- 2) Press the center button to select the 'Change AutoSample' option and to enter the change autosample submenu.
- 3) Use the left or right buttons to scroll through autosample value options of Off, After power fail, or External control.
- 4) Press the center button, 'OK' to select the current autosample value option. Once selected, the value is saved and the user interface menu is automatically returned to the top menu level.

5.8.3.11. Display All Settings (terminal emulator interface only)

The on-board user interface on the front of the microAeth is used to send all settings information including the FlowCal information of the instrument via the 4-pin serial port. Displaying all settings of the microAeth can be accomplished through the serial port to a terminal emulator on a computer using the AethLabs 4-pin Serial to USB converter cable. The serial output of Display All Settings is shown and described in section 7.2. Display and Check All Settings.

Before using the AethLabs 4-pin Serial to USB converter cable, it may be required to install drivers from Future Technology Devices International Ltd. (FTDI) in order for the converter cable to be recognized by and used with the computer.

- 1) Unplug the microAeth from all external power sources.
- 2) Plug in the AethLabs Serial to USB converter cable to the 4-pin serial port of the microAeth. Plug in the USB A plug of the cable into a computer where data will be downloaded.
- 3) Open a terminal emulator (AethLabs only supports Tera Term for Windows) on the computer and use the following default settings (as described in section 5.5.3. 3.3V TTL Serial) or the serial baud rate setting as has been changed by the user:

Baud Rate	Data	Parity	Stop	Flow control
1000000 (default)	8 bit	none	1 bit	none (Xon/Xoff for firmware update)

- 4) When Tera Term opens, a window with the title 'Tera Term: New connection' will appear.
- 5) Select the 'Serial' radio button.
- 6) Use the 'Port:' dropdown menu to select the COM port that the microAeth is connected to through the AethLabs 4-pin Serial to USB converter cable.
- 7) Press 'OK'.
- 8) The main window will remain and the window title will now be the COM port number.
- 9) Select the 'Setup' menu and select 'Serial port...'
- 10) In the 'Tera Term: Serial port setup' window, change the settings to match the communication settings in Step 3.
- 11) Press 'OK'.
- 12) The terminal emulator should now display the on-board user interface options as the 3 button interface is used by the user. More information that is hidden on the microAeth on-board screen will be displayed in the terminal emulator.
- 13) Use the left and right buttons to scroll through the top level menu options to 'Display All Settings'.

- 14) Press the center button to select the 'Display All Settings' option.
- 15) 'Sent via Serial Port' will display on the screen and all settings, status, and flow calibration table information will be displayed in the terminal emulator.

5.8.3.12. Display FlowCal Info (terminal emulator interface only)

The on-board user interface on the front of the microAeth is used to send all all FlowCal information of the instrument via the 4-pin serial port. Displaying FlowCal information of the microAeth can be accomplished through the serial port to a terminal emulator on a computer using the AethLabs 4-pin Serial to USB converter cable. The serial output of Display FlowCal Info is shown and described in section 7.3.2. Display and Check Flow Calibration Table.

Before using the AethLabs 4-pin Serial to USB converter cable, it may be required to install drivers from Future Technology Devices International Ltd. (FTDI) in order for the converter cable to be recognized by and used with the computer.

- 1) Unplug the microAeth from all external power sources.
- 2) Plug in the AethLabs Serial to USB converter cable to the 4-pin serial port of the microAeth. Plug in the USB A plug of the cable into a computer where data will be downloaded.
- 3) Open a terminal emulator (AethLabs only supports Tera Term for Windows) on the computer and use the following default settings (as described in section 5.5.3. 3.3V TTL Serial) or the serial baud rate setting as has been changed by the user:

Baud Rate	Data	Parity	Stop	Flow control
1000000 (default)	8 bit	none	1 bit	none (Xon/Xoff for firmware update)

- 4) When Tera Term opens, a window with the title 'Tera Term: New connection' will appear.
- 5) Select the 'Serial' radio button.
- 6) Use the 'Port:' dropdown menu to select the COM port that the microAeth is connected to through the AethLabs 4-pin Serial to USB converter cable.
- 7) Press 'OK'.
- 8) The main window will remain and the window title will now be the COM port number.
- 9) Select the 'Setup' menu and select 'Serial port...'
- 10) In the 'Tera Term: Serial port setup' window, change the settings to match the communication settings in Step 3.
- 11) Press 'OK'.
- 12) The terminal emulator should now display the on-board user interface options as the 3 button interface is used by the user. More information that is hidden on the microAeth on-board screen will be displayed in the terminal emulator.
- 13) Use the left and right buttons to scroll through the top level menu options to 'Display FlowCal Info'.
- 14) Press the center button to select the 'Display FlowCal Info' option.
- 15) 'Sent via Serial Port' will display on the screen and the flow calibration table information will be displayed in the terminal emulator.

5.8.3.13. Turn Off

The on-board user interface on the front of the microAeth can be used to turn off the instrument.

- 1) Use the left and right buttons to scroll through the top level menu options to 'Turn Off'.
- 2) Press the center button to select the 'Turn Off' option. The screen and instrument will turn off.

5.8.4. On-board Status Indications

5.8.4.1. Serial Number

The on-board screen displays the serial number of the microAeth in the top left corner.

5.8.4.2. Battery

The on-board screen displays the percentage battery remaining in the top right corner.

5.8.4.3. Charging

When the instrument is connected to an external power source using the 5V barrel jack port and the battery is charging, the on-board screen displays “P” to the right of the percentage battery remaining in the top right corner. While the USB port can be used to charge the instrument, the charging indicator will not be displayed.

5.8.4.4. Startup

The on-board screen displays additional status indications at startup when the instrument is turned on. At startup, the following information is temporarily displayed:

AethLabs MA Series

Version: x.xx <Displays the firmware version>

Serial Baud: xxxxxx <Displays the current serial baud rate value>

AutoSample:xxx <Displays the current AutoSample setting value>

5.9. Command Line Interface (CLI) for Polled Serial Data Mode

The command line interface (CLI) can be used to control and request status information and data from the microAeth when the instrument serial data mode is set to polled.

The following default settings (as described in section 5.5.3. 3.3V TTL Serial) or the serial baud rate setting as has been changed by the user are used to communicate with the microAeth through the serial port.

Baud Rate	Data	Parity	Stop	Flow control
1000000 (default)	8 bit	none	1 bit	none (Xon/Xoff for firmware update)

The microAeth has a 4-pin serial port for communication through 3.3V TTL serial with external data acquisition systems or for direct integration into another system. Communication through the 3.3V TTL serial port can be established to a computer through a terminal emulator using the custom AethLabs 4-pin Serial to USB converter cable.

NOTE: The serial baud rate can be changed using the on-board LCD interface and the Change Serial Baud menu or using the microAeth Manager and the Baud rate setting under Serial and Communications.

5.9.1. AethLabs Serial Protocol

The following AethLabs Serial Protocol commands can be used in polled serial data mode:

AethLabs Serial Protocol		
To issue a command, send command + carriage return (<CR>, ASCII code 0x0D)		
Name	Command	Description / Response
Data request	dr	Requests most recent recorded data line. Most recent data line is returned in either Verbose or Minimal serial data format depending on instrument setting. See section 6.2. Serial Data Format Structures.
Measurement start / stop	ms	Instrument starts or stops sampling and measurements depending on current state of the instrument.
Check status	cs	Requests current status of instrument. The following is returned: 'firstId = <aaaa>, nextId = <bbbb>, currentId = <cccc>, sampling = <0=false or 1=true>' where aaaa, bbbb, cccc = Whole numbers.
Check battery	cb	Requests current remaining battery. The following is returned: 'Battery Perc : <xxx>' where xxx = Whole number (0-100).
Activate left button	ul	Simulates a physical push of the left button of the on-board user interface.
Activate center button	uc	Simulates a physical push of the center button of the on-board user interface.
Activate right button	ur	Simulates a physical push of the right button of the on-board user interface.

5.9.2. Bayern-Hessen Protocol

This section describes Hessen network protocol as implemented in AethLabs' MA Series instruments. The MA Series instruments act as a slave to a remote host communicating over the MA Series instrument serial port. The following AethLabs Bayern-Hessen Protocol implementation can be used in polled serial data mode:

Requirements:

- Physical connection from host device to MA Series instrument serial port.
- Serial Baud configuration matching on both the Host and MA Series instrument devices
- Serial Data setting must be set to 'Polled'

Bayern-Hessen Protocol Abbreviations Used		
Message Field	Length (bytes)	Description
<CR>	1	Carriage return (ASCII code 0x0D)
<STX>	1	Start of text character (ASCII code 0x02)
<ETX>	1	End of text character (ASCII code 0x03)
<BCC>	2	Block checksum characters
<SP>	1	Space character (ASCII code 0x20)

Bayern-Hessen Protocol Basic Command Structure
<STX>Command message<ETX><BCC>
OR
Command message<CR>

Each command is framed by either <STX> at the start and terminated with <ETX> or without a start and terminated only with <CR>. If a command is terminated with <ETX> then additional two characters <BCC> block checksum is attached after <ETX>.

AethLabs' implementation of the Hessen protocol does not itself support multi-drop installations, the instrument instead responds to broadcast command messages that do not specify an instrument ID. As the MA Series instruments do not have a traditional zero or span mode, normally associated with gas monitors, this functionality is not supported. MA Series instrument serial ports are 3.3v TTL logic level serial. Care must be taken when interfacing to this hardware as it is not isolated. Minimum serial baud rate communication speed for the MA Series instruments is 57600 baud.

Command for AethLabs Implementation of Bayern-Hessen Protocol		
Command Message	Description	Examples
DA	Data Query Command	<STX>DA<ETX><BCC> (<STX>DA<ETX>04) OR DA<CR>

NOTE: It is possible to make the same request simply by sending 'DA <CR>' not using <STX>, <ETX>, and <BCC>.

Bayern-Hessen Protocol Response Message Fields		
Message Field	Length (bytes)	Description
<STX>	1	Start of text character (ASCII code 0x02)
MD	2	'MD' is the message header.
<aa>	2	This is the number of gases (AethLabs measurements) being reported in the message
<SP>	1	Space character (ASCII code 0x20)
<nnn>	3	Three-digit gas (AethLabs measurement) ID number.
<SP>	1	Space character (ASCII code 0x20)
<smmmsee>	8	Gas (AethLabs measurement) concentration.
<SP>	1	Space character (ASCII code 0x20)
<oo>	2	8 operational status bits, formatted as a two digit hexadecimal number.
<SP>	1	Space character (ASCII code 0x20)
<ff>	2	8 failure status bits, formatted as a two digit hexadecimal number.
<SP>	1	Space character (ASCII code 0x20)
<iii>	3	Three-digit instrument ID number.
<SP>	1	Space character (ASCII code 0x20)
000000	6	Spare field. Set to all zeros.
<SP>	1	Space character (ASCII code 0x20)
<ETX>	1	End of text character (ASCII code 0x03)
<BCC>	2	Block checksum
TOTAL	9 + 30 x A	'A' is the number of gases (AethLabs measurements) being reported in the message.

Response Message for AethLabs Implementation of Bayern-Hessen Protocol
Complete Response for Data Query Command (DA):
<STX>MD<aa><nnn><SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP><SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP><SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP><SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP><SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP><ETX><BCC>
Preamble of Response:
<STX>MD<aa><nnn>
For each data line measurement returned: (e.g. UV BC1, Blue BC1, Green BC1, Red BC1, IR BC1, FlowTotal, Tape Postion):
<SP><smmmsee><SP><oo><SP><ff><SP><iii><SP>000000<SP>
End of Response:
<ETX><BCC>

If the instrument is in SingleSpot mode, BC1 value for each optical wavelength will be returned. If the instrument is in DualSpot mode, the BCc (compensated) value for each optical wavelength will be returned. The instrument will provide the following channel values in response to a 'DA' command message:

Response Message for AethLabs Implementation of Bayern-Hessen Protocol		
Measurement / Status Data	Units / Format	
SingleSpot mode:		
UV BC1	Nanograms per cubic meter (ng/m ³) (Integer)	
Blue BC1	Nanograms per cubic meter (ng/m ³) (Integer)	
Green BC1	Nanograms per cubic meter (ng/m ³) (Integer)	
Red BC1	Nanograms per cubic meter (ng/m ³) (Integer)	
IR BC1	Nanograms per cubic meter (ng/m ³) (Integer)	
FlowTotal	Milliliters per minute (ml/min) (Decimal number)	
Tape Position	Whole number	
DualSpot mode:		
UV BCc	Nanograms per cubic meter (ng/m ³) (Integer)	
Blue BCc	Nanograms per cubic meter (ng/m ³) (Integer)	
Green BCc	Nanograms per cubic meter (ng/m ³) (Integer)	
Red BCc	Nanograms per cubic meter (ng/m ³) (Integer)	
IR BCc	Nanograms per cubic meter (ng/m ³) (Integer)	
FlowTotal	Milliliters per minute (ml/min) (Decimal number)	
Tape Position	Whole number	

6. Viewing and Analyzing Measurement Data

6.1. Data File Structure

The data files exported through the microAeth Manager are plain text with the extension .csv. Each data file consists of a header containing descriptive information; a line identifying the data columns; and then a number of data lines with each item separated by a comma. As the microAeth is starting a new sampling and measurement session, the first few minutes of data do not contain the BC calculation; all subsequent lines of data show this value except during an automatic tape advance.

Exported Data File Structure:

Serial number, Datum ID, Session ID, Data format version, Firmware version, App version, Date / time local, Timezone offset (mins), Date local (yyyy/MM/dd), Time local (hh:mm:ss), GPS lat (ddmm.mmmmm), GPS long (dddmm.mmmmm), GPS speed (km/h), GPS sat count, Timebase (s), Status, Battery remaining (%), Accel X, Accel Y, Accel Z, Tape position, Flow setpoint (mL/min), Flow total (mL/min), Flow1 (mL/min), Flow2 (mL/min), Sample temp (C), Sample RH (%), Sample dewpoint (C), Internal pressure (Pa), Internal temp (C), Optical config, UV Sen1, UV Sen2, UV Ref, UV ATN1, UV ATN2, UV K, Blue Sen1, Blue Sen2, Blue Ref, Blue ATN1, Blue ATN2, Blue K, Green Sen1, Green Sen2, Green Ref, Green ATN1, Green ATN2, Green K, Red Sen1, Red Sen2, Red Ref, Red ATN1, Red ATN2, Red K, IR Sen1, IR Sen2, IR Ref, IR ATN1, IR ATN2, IR K, UV BC1, UV BC2, UV BCc, Blue BC1, Blue BC2, Blue BCc, Green BC1, Green BC2, Green BCc, Red BC1, Red BC2, Red BCc, IR BC1, IR BC2, IR BCc

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
Serial number	Model and number (MAxxx-xxxx)	MA200-0001	Unique identification number for the Instrument.
Datum ID	Whole number	1	Identification number assigned to each line of recorded data.
Session ID	Whole number	1	Identification number assigned to each sampling and measurement session. This value is incremented each time a new sampling and measurement session is started (changes from STOPPED to SAMPLING mode).
Data format version	Natural number	1	Unique identification number for exported data file structure used when exporting data from microAeth Manager software.
Firmware version	Decimal number	1.08	Unique identification number for firmware running on instrument when measurement was recorded.
App version	Decimal number	1.03	Unique identification number for microAeth Manager software that was used to export data file.
Date / time local	Year, month, day, hours, minutes, seconds (yyyy-MM-ddTxx:xx:xx)	2018-03-21T14:17:00	Local date and time calculated from instrument's internal clock using Coordinated Universal Time (UTC) and Timezone offset.
Timezone offset (mins)	Minutes (Integer)	-420	Timezone offset from Coordinated Universal Time (UTC) in minutes.
Date local (yyyy/MM/dd)	Year, month, day (yyyy/MM/dd)	2018/03/21	Local date calculated from instrument's internal clock using Coordinated Universal Time (UTC) and Timezone offset.

Example Response Message for AethLabs Implementation of Bayern-Hessen Protocol

The following hypothetical dataline (DualSpot) that might be available on the instrument at the time the 'DA' command message is issued:

```
MA200-0011,25157,18,1,1.08,2018-12-06T20:29:01.00,-480,37.746172547,-122.
420371919,0.146,60,64,100,342,-611,
-24357,1,100.00,99.99,58.56,41.43,32.95,23.97,9.69,100596.00,33.62,DS-UV-B-G-R-IR,
681907,622183,917573,25.9730,18.4158,-0.0198,780829,620878,736176,19.5300,13.7320,
-0.0103,781964,625168,706936,16.6708,11.6571,0.0168,806763,690497,782392,13.4350,9.3264,
-0.0353,675814,773992,951767,9.4010,6.3921,
-0.1671,415,374,274,396,376,330,427,478,594,377,340,255,510,410,198,5D91
```

Expected response message:

```
MD07 001 +2740+02 00 00 011 000000 002 +3300+02 00 00 011 000000 003 +5940+02 00 00 011
000000 004 +2550+02 00 00 011 000000 005 +1980+02 00 00 011 000000 006 +1000+02 00 00 011
000000 007 +1000+00 00 00 011 000000
```

Expected response message values:

UV BCc	274
Blue BCc	330
Green BCc	594
Red BCc	255
IR BCc	198
FlowTotal	100
Tape Position	1

5.10. Filter Media

The sample collection and analysis is performed on a roll of polytetrafluoroethylene (PTFE) filter tape that is housed in the filter tape cartridge. As the aerosol sample is drawn through the filter media by the instrument's integrated, internal sample pump, the aerosol sample collects gradually on the filter medium to create a gray spot 3mm in diameter. The microAeth determines the optical attenuation as the accumulated particles increase the optical density of the filter spot. After the optical density reaches a certain level, which is set by the ATN Tape Trigger setting, the filter spot must be replaced to maintain measurement integrity. The filter tape roll is automatically advanced to provide a new clean spot location for sampling. **IMPORTANT: Do not rewind the filter tape cartridge, or use previously sampled filter tape sampling locations.**

The tape position counter counts each time the filter tape cartridge advances. This counter is reset every time the tape clamp mechanism is released and then reclamped. The instrument does not specifically know the position of the filter tape in the filter tape cartridge in relation to the beginning or end of a filter tape cartridge. The user is responsible for keeping track of this process using the counter as a guide. The instrument is able to know and notify the user when a filter tape cartridge has reached the end of the tape.

5.11. Data Safety

AethLabs highly recommends keeping a pristine backup of the original data collected on the instrument in an exported file.

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
Time local (hh:mm:ss)	Hours, minutes, seconds (hh:mm:ss)	14:17:00	Local time calculated from instrument's internal clock using Coordinated Universal Time (UTC) and Timezone offset.
GPS lat (ddmm.mmmmm)	Degrees (ddmm.mmmmm)	37.7461101412773	Measured latitude or relative angular distance north or south on Earth's surface in degrees from the equator.
GPS long (dddmm.mmmmm)	Degrees (dddmm.mmmmm)	-122.420443087816	Measured longitude or relative angular distance east or west on Earth's surface in degrees from the prime meridian.
GPS speed (km/h)	Kilometers per hour (Decimal number)	0.144168466329574	Measured speed using GPS in kilometers per hour. GPS is based on GPS lat and long, which are required for GPS speed calculation.
GPS sat count	Whole number	3	Number of satellites that are visible to the instrument's internal GPS receiver.
Timebase (s)	Seconds (Natural number)	60	Value in seconds of the measurement interval between measurements.
Status	Whole number	1	See section 6.3. Status Codes for detailed information.
Battery remaining (%)	Percent (Whole number)	88	Percent of instrument internal battery remaining.
Accel X	Integer	-5	Measured instantaneous acceleration in the x-axis.
Accel Y	Integer	-8	Measured instantaneous acceleration in the y-axis.
Accel Z	Integer	-255	Measured instantaneous acceleration in the z-axis.
Tape position	Whole number	1	Value of tape position counter. Increments by 1 after each tape advance. Counter is reset when 'Release Tape' is used to release the tape cartridge no matter the position of the newly inserted tape cartridge.
Flow setpoint (mL/min)	Milliliters per minute (Whole number)	100	Target value of the instrument total flow rate in milliliters per minute. Used in SingleSpot™ and DualSpot® sampling modes.
Flow total (mL/min)	Milliliters per minute (Decimal number)	100.10	Measured total flow through the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow1 (mL/min)	Milliliters per minute (Decimal number)	60.23	Measured flow through sample spot sense1 of the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow2 (mL/min)	Milliliters per minute (Decimal number)	39.87	Calculated flow through sample spot sense2 of the instrument in milliliters per minute. Calculated in DualSpot® sampling mode. No flow in SingleSpot™ sampling mode.
Sample temp (C)	Degrees celsius (Decimal number)	26.6705474853515	Measured temperature of instrument sampling stream in degrees celsius.
Sample RH (%)	Percent (Decimal number)	22.6140441894531	Measured relative humidity of instrument sampling stream in percent.
Sample dewpoint (C)	Degrees celsius (Decimal number)	10.3270139694213	Calculated temperature of dewpoint of instrument sampling stream in degrees celsius.
Internal pressure (Pa)	Pascal (Natural number)	100692	Measured pressure inside instrument case in pascals.
Internal temp (C)	Degrees celsius (Decimal number)	35.375	Measured temperature inside instrument case in Celsius.

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
Optical config	<DUAL or SINGLE>SPOT-XX-XXXX-XXXX-XXX-XX	DUALSPOT-UV-BLUE-GREEN-RED-IR	Identification of sampling mode (SingleSpot™ or DualSpot®) and only the optical wavelengths used for each measurement are displayed.
UV Sen1	Counts (Whole number)	710434	Measured optical intensity of ultraviolet (UV) wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
UV Sen2	Counts (Whole number)	724526	Measured optical intensity of ultraviolet (UV) wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
UV Ref	Counts (Whole number)	907699	Measured optical intensity of ultraviolet (UV) wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
UV ATN1	Attenuation units (Decimal number)	20.031862	Calculated attenuation of ultraviolet (UV) wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
UV ATN2	Attenuation units (Decimal number)	12.559727	Calculated attenuation of ultraviolet (UV) wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
UV K	Unitless (Decimal number)	0.0046992627903819	Calculated loading compensation factor for ultraviolet (UV) wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Blue Sen1	Counts (Whole number)	751124	Measured optical intensity of blue wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Blue Sen2	Counts (Whole number)	759335	Measured optical intensity of blue wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Blue Ref	Counts (Whole number)	843783	Measured optical intensity of blue wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Blue ATN1	Attenuation units (Decimal number)	15.778888	Calculated attenuation of blue wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Blue ATN2	Attenuation units (Decimal number)	9.550997	Calculated attenuation of blue wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Blue K	Unitless (Decimal number)	0.00198470731265842	Calculated loading compensation factor for blue wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Green Sen1	Counts (Whole number)	810122	Measured optical intensity of green wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Green Sen2	Counts (Whole number)	829080	Measured optical intensity of green wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Green Ref	Counts (Whole number)	902411	Measured optical intensity of green wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
Green ATN1	Attenuation units (Decimal number)	13.872042	Calculated attenuation of green wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Green ATN2	Attenuation units (Decimal number)	8.236315	Calculated attenuation of green wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Green K	Unitless (Decimal number)	0.00123747368343174	Calculated loading compensation factor for green wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Red Sen1	Counts (Whole number)	794974	Measured optical intensity of red wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Red Sen2	Counts (Whole number)	759396	Measured optical intensity of red wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Red Ref	Counts (Whole number)	888090	Measured optical intensity of red wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Red ATN1	Attenuation units (Decimal number)	11.366656	Calculated attenuation of red wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Red ATN2	Attenuation units (Decimal number)	6.714724	Calculated attenuation of red wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Red K	Unitless (Decimal number)	-0.00194589456077665	Calculated loading compensation factor for red wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
IR Sen1	Counts (Whole number)	657342	Measured optical intensity of infrared (IR) wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
IR Sen2	Counts (Whole number)	792594	Measured optical intensity of infrared (IR) wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
IR Ref	Counts (Whole number)	976403	Measured optical intensity of infrared (IR) wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
IR ATN1	Attenuation units (Decimal number)	8.610901	Calculated attenuation of infrared (IR) wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
IR ATN2	Attenuation units (Decimal number)	5.190925	Calculated attenuation of infrared (IR) wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
IR K	Unitless (Decimal number)	-0.00266132899560034	Calculated loading compensation factor for infrared (IR) wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
UV BC1	Nanograms per cubic meter (ng/m³) (Integer)	23201	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
UV BC2	Nanograms per cubic meter (ng/m³) (Integer)	24101	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
UV BCc	Nanograms per cubic meter (ng/m³) (Integer)	25613	Calculated mass concentration with DualSpot® loading compensation for ultraviolet (UV) wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Blue BC1	Nanograms per cubic meter (ng/m³) (Integer)	24325	Calculated mass concentration for blue wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Blue BC2	Nanograms per cubic meter (ng/m³) (Integer)	24635	Calculated mass concentration for blue wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Blue BCc	Nanograms per cubic meter (ng/m³) (Integer)	25111	Calculated mass concentration with DualSpot® loading compensation for blue wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Green BC1	Nanograms per cubic meter (ng/m³) (Integer)	24088	Calculated mass concentration for green wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Green BC2	Nanograms per cubic meter (ng/m³) (Integer)	24259	Calculated mass concentration for green wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Green BCc	Nanograms per cubic meter (ng/m³) (Integer)	24509	Calculated mass concentration with DualSpot® loading compensation for green wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Red BC1	Nanograms per cubic meter (ng/m³) (Integer)	24137	Calculated mass concentration for red wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Red BC2	Nanograms per cubic meter (ng/m³) (Integer)	23923	Calculated mass concentration for red wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Red BCc	Nanograms per cubic meter (ng/m³) (Integer)	23615	Calculated mass concentration with DualSpot® loading compensation for red wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
IR BC1	Nanograms per cubic meter (ng/m³) (Integer)	23958	Calculated mass concentration for infrared (IR) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
IR BC2	Nanograms per cubic meter (ng/m³) (Integer)	23745	Calculated mass concentration for infrared (IR) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.

Exported Data File Structure Details			
Header	Units / Format	Example Data	Description
IR BCc	Nanograms per cubic meter (ng/m ³) (Integer)	23422	Calculated mass concentration with DualSpot® loading compensation for infrared (IR) wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Readable status	Text	Start up	Human readable description of status codes. See section 6.3. Status Codes for detailed information.

6.2. Serial Data Format Structures

The format structures of the measurement serial data in streaming and polled serial data modes that are output through the 4-pin serial port of the microAeth are as follows.

6.2.1. Verbose Structure

SingleSpot® sampling mode:

5 Wavelengths:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, UV Sen1, UV Ref, UV ATN1, Blue Sen1, Blue Ref, Blue ATN1, Green Sen1, Green Ref, Green ATN1, Red Sen1, Red Ref, Red ATN1, IR Sen1, IR Ref, IR ATN1, UV BC1, Blue BC1, Green BC1, Red BC1, IR BC1, CKSUM

UV + IR Wavelengths:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, UV Sen1, UV Ref, UV ATN1, IR Sen1, IR Ref, IR ATN1, UV BC1, IR BC1, CKSUM

Only IR Wavelength:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, IR Sen1, IR Ref, IR ATN1, IR BC1, CKSUM

DualSpot® sampling mode:

5 Wavelengths:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Flow1, Flow2, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, UV Sen1, UV Sen2, UV Ref, UV ATN1, UV ATN2, UV K, Blue Sen1, Blue Sen2, Blue Ref, Blue ATN1, Blue ATN2, Blue K, Green Sen1, Green Sen2, Green Ref, Green ATN1, Green ATN2, Green K, Red Sen1, Red Sen2, Red Ref, Red ATN1, Red ATN2, Red K, IR Sen1, IR Sen2, IR Ref, IR ATN1, IR ATN2, IR K, UV BC1, UV BC2, UV BCc, Blue BC1, Blue BC2, Blue BCc, Green BC1, Green BC2, Green BCc, Red BC1, Red BC2, Red BCc, IR BC1, IR BC2, IR BCc, CKSUM

UV + IR Wavelengths:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Flow1, Flow2, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, UV Sen1, UV Sen2, UV Ref, UV ATN1, UV ATN2, UV K, IR Sen1, IR Sen2, IR Ref, IR ATN1, IR ATN2, IR K, UV BC1, UV BC2, UV BCc, IR BC1, IR BC2, IR BCc, CKSUM

Only IR Wavelength:

Serial number, Datum ID, Session ID, Data format version, Firmware version, Date / Time GMT, Timezone offset, GPS lat, GPS long, GPS Speed, Timebase, Status, Battery, Accel X, Accel Y, Accel Z, Tape position, Flow setpoint, Flow total, Flow1, Flow2, Sample temp, Sample RH, Sample dewpoint, Int pressure, Int temp, Optical config, IR Sen1, IR Sen2, IR Ref, IR ATN1, IR ATN2, IR K, IR BC1, IR BC2, IR BCc, CKSUM

Verbose Structure Details			
Header	Units / Format	Example Data	Description
Serial number	Model and number (MAxxx-xxxx)	MA200-0011	Unique identification number for the Instrument.
Datum ID	Whole number	1	Identification number assigned to each line of recorded data.
Session ID	Whole number	1	Identification number assigned to each sampling and measurement session. This value is incremented each time a new sampling and measurement session is started (changes from STOPPED to SAMPLING mode).
Data format version	Natural number	1	Unique identification number for exported data file structure used when exporting data from microAeth Manager software.
Firmware version	Decimal number	1.08	Unique identification number for firmware running on instrument when measurement was recorded.
Date / Time GMT	Year, month, day, hours, minutes, seconds (yyyy-MM-ddTxx:xx:xx.xx)	2018-03-21T14:17:00.00	Local date and time produced from instrument's internal clock using Coordinated Universal Time (UTC) and Timezone offset.
Timezone offset	Minutes (Integer)	-420	Timezone offset from Coordinated Universal Time (UTC) in minutes.
GPS lat	Degrees (ddmm.mmmmm)	37.7461101412773	Measured latitude or relative angular distance north or south on Earth's surface in degrees from the equator.
GPS long	Degrees (dddmm.mmmmm)	-122.420443087816	Measured longitude or relative angular distance east or west on Earth's surface in degrees from the prime meridian.
GPS speed	Kilometers per hour (Decimal number)	0.144168466329574	Measured speed using GPS in kilometers per hour. GPS is based on GPS lat and long, which are required for GPS speed calculation.
Timebase	Seconds (Natural number)	60	Value in seconds of the measurement interval between measurements.
Status	Whole number	1	See section 6.3. Status Codes for detailed information.
Battery	Percent (Whole number)	88	Percent of instrument internal battery remaining.
Accel X	Integer	-5	Measured instantaneous acceleration in the x-axis.

Verbose Structure Details			
Header	Units / Format	Example Data	Description
Accel Y	Integer	-8	Measured instantaneous acceleration in the y-axis.
Accel Z	Integer	-255	Measured instantaneous acceleration in the z-axis.
Tape position	Whole number	1	Value of tape position counter. Increments by 1 after each tape advance. Counter is reset when 'Release Tape' is used to release the tape cartridge no matter the position of the newly inserted tape cartridge.
Flow setpoint	Milliliters per minute (Whole number)	100	Target value of the instrument total flow rate in milliliters per minute. Used in SingleSpot™ and DualSpot® sampling modes.
Flow total	Milliliters per minute (Decimal number)	100.10	Measured total flow through the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow1	Milliliters per minute (Decimal number)	60.23	Measured flow through sample spot sense1 of the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow2	Milliliters per minute (Decimal number)	39.87	Calculated flow through sample spot sense2 of the instrument in milliliters per minute. Calculated in DualSpot® sampling mode. No flow in SingleSpot™ sampling mode.
Sample temp	Degrees celsius (Decimal number)	26.6705474853515	Measured temperature of instrument sampling stream in degrees celsius.
Sample RH	Percent (Decimal number)	22.6140441894531	Measured relative humidity of instrument sampling stream in percent.
Sample dewpoint	Degrees celsius (Decimal number)	10.3270139694213	Calculated temperature of dewpoint of instrument sampling stream in degrees celsius.
Int pressure	Pascal (Natural number)	100692	Measured pressure inside instrument case in pascals.
Int temp	Degrees celsius (Decimal number)	35.375	Measured temperature inside instrument case in Celsius.
Optical config	<SS or DS>-XX-X-X-X-XX	DS-UV-B-G-R-IR	Identification of sampling mode (SingleSpot™ (SS) or DualSpot® (DS)) and only the optical wavelengths used for each measurement are displayed.
UV Sen1	Counts (Whole number)	710434	Measured optical intensity of ultraviolet (UV) wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
UV Sen2	Counts (Whole number)	724526	Measured optical intensity of ultraviolet (UV) wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
UV Ref	Counts (Whole number)	907699	Measured optical intensity of ultraviolet (UV) wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
UV ATN1	Attenuation units (Decimal number)	20.031862	Calculated attenuation of ultraviolet (UV) wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
UV ATN2	Attenuation units (Decimal number)	12.559727	Calculated attenuation of ultraviolet (UV) wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.

Verbose Structure Details			
Header	Units / Format	Example Data	Description
UV K	Unitless (Decimal number)	0.0046992627903819	Calculated loading compensation factor for ultraviolet (UV) wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Blue Sen1	Counts (Whole number)	751124	Measured optical intensity of blue wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Blue Sen2	Counts (Whole number)	759335	Measured optical intensity for blue wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Blue Ref	Counts (Whole number)	843783	Measured optical intensity of blue wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Blue ATN1	Attenuation units (Decimal number)	15.778888	Calculated attenuation of blue wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Blue ATN2	Attenuation units (Decimal number)	9.550997	Calculated attenuation of blue wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Blue K	Unitless (Decimal number)	0.00198470731265842	Calculated loading compensation factor for blue wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Green Sen1	Counts (Whole number)	810122	Measured optical intensity of green wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Green Sen2	Counts (Whole number)	829080	Measured optical intensity of green wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Green Ref	Counts (Whole number)	902411	Measured optical intensity of green wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Green ATN1	Attenuation units (Decimal number)	13.872042	Calculated attenuation of green wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Green ATN2	Attenuation units (Decimal number)	8.236315	Calculated attenuation of green wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Green K	Unitless (Decimal number)	0.00123747368343174	Calculated loading compensation factor for green wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
Red Sen1	Counts (Whole number)	794974	Measured optical intensity of red wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
Red Sen2	Counts (Whole number)	759396	Measured optical intensity of red wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
Red Ref	Counts (Whole number)	888090	Measured optical intensity of red wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.

Verbose Structure Details			
Header	Units / Format	Example Data	Description
Red ATN1	Attenuation units (Decimal number)	11.366656	Calculated attenuation of red wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
Red ATN2	Attenuation units (Decimal number)	6.714724	Calculated attenuation of red wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
Red K	Unitless (Decimal number)	-0.00194589456077665	Calculated loading compensation factor for red wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
IR Sen1	Counts (Whole number)	657342	Measured optical intensity of infrared (IR) wavelength for sample spot sense1 in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
IR Sen2	Counts (Whole number)	792594	Measured optical intensity of infrared (IR) wavelength for sample spot sense2 in counts. Measured in DualSpot® sampling mode.
IR Ref	Counts (Whole number)	976403	Measured optical intensity of infrared (IR) wavelength for reference spot in counts. Measured in SingleSpot™ and DualSpot® sampling modes.
IR ATN1	Attenuation units (Decimal number)	8.610901	Calculated attenuation of infrared (IR) wavelength for sample spot sense1 in attenuation units. Calculated in SingleSpot™ and DualSpot® sampling modes.
IR ATN2	Attenuation units (Decimal number)	5.190925	Calculated attenuation of infrared (IR) wavelength for sample spot sense2 in attenuation units. Calculated in DualSpot® sampling mode.
IR K	Unitless (Decimal number)	-0.00266132899560034	Calculated loading compensation factor for infrared (IR) wavelength using sample spots sense1 and sense2, used to compensate BC1 value resulting in BCc. Calculated in DualSpot® sampling mode.
UV BC1	Nanograms per cubic meter (ng/m³) (Integer)	23201	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
UV BC2	Nanograms per cubic meter (ng/m³) (Integer)	24101	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
UV BCc	Nanograms per cubic meter (ng/m³) (Integer)	25613	Calculated mass concentration with DualSpot® loading compensation for ultraviolet (UV) wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Blue BC1	Nanograms per cubic meter (ng/m³) (Integer)	24325	Calculated mass concentration for blue wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Blue BC2	Nanograms per cubic meter (ng/m³) (Integer)	24635	Calculated mass concentration for blue wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Blue BCc	Nanograms per cubic meter (ng/m³) (Integer)	25111	Calculated mass concentration with DualSpot® loading compensation for blue wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.

Verbose Structure Details			
Header	Units / Format	Example Data	Description
Green BC1	Nanograms per cubic meter (ng/m³) (Integer)	24088	Calculated mass concentration for green wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Green BC2	Nanograms per cubic meter (ng/m³) (Integer)	24259	Calculated mass concentration for green wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Green BCc	Nanograms per cubic meter (ng/m³) (Integer)	24509	Calculated mass concentration with DualSpot® loading compensation for green wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Red BC1	Nanograms per cubic meter (ng/m³) (Integer)	24137	Calculated mass concentration for red wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
Red BC2	Nanograms per cubic meter (ng/m³) (Integer)	23923	Calculated mass concentration for red wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
Red BCc	Nanograms per cubic meter (ng/m³) (Integer)	23615	Calculated mass concentration with DualSpot® loading compensation for red wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
IR BC1	Nanograms per cubic meter (ng/m³) (Integer)	23958	Calculated mass concentration for infrared (IR) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
IR BC2	Nanograms per cubic meter (ng/m³) (Integer)	23745	Calculated mass concentration for infrared (IR) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
IR BCc	Nanograms per cubic meter (ng/m³) (Integer)	23422	Calculated mass concentration with DualSpot® loading compensation for infrared (IR) wavelength using sample spots sense1 and sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
CKSUM	Alphanumeric (XXXX)	434B	

6.2.2. Minimal Structure

SingleSpot™ sampling mode:

Preamble, Date / Time GMT, Timezone offset, Status, Battery, Tape position, Flow total, UV BC, IR BC, CKSUM

DualSpot® sampling mode:

Preamble, Date / Time GMT, Timezone offset, Status, Battery, Tape position, Flow total, Flow1, Flow2, UV BC1, UV BC2, IR BC1, IR BC2, CKSUM

Minimal Structure Details			
Header	Units / Format	Example Data	Description
Preamble	Alphanumeric (XXXXXX)	55AAFF	Identification for serial data stream format.
Date / Time GMT	Year, month, day, hours, minutes, seconds (yyyy-MM-ddTxx:xx:xx.xx)	2018-03-21T14:17:00.00	Local date and time produced from instrument's internal clock using Coordinated Universal Time (UTC).
Timezone offset	Minutes (Integer)	-420	Timezone offset from Coordinated Universal Time (UTC) in minutes.
Status	Whole number	1	See section 6.3. Status Codes for detailed information.
Battery	Percent (Whole number)	88	Percent of instrument internal battery remaining.
Tape position	Whole number	1	Value of tape position counter. Increments by 1 after each tape advance. Counter is reset when 'Release Tape' is used to release the tape cartridge no matter the position of the newly inserted tape cartridge.
Flow total	Milliliters per minute (Decimal number)	100.10	Measured total flow through the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow1	Milliliters per minute (Decimal number)	60.23	Measured flow through sample spot sense1 of the instrument in milliliters per minute. Measured in SingleSpot™ and DualSpot® sampling modes.
Flow2	Milliliters per minute (Decimal number)	39.87	Calculated flow through sample spot sense2 of the instrument in milliliters per minute. Calculated in DualSpot® sampling mode. No flow in SingleSpot™ sampling mode.
UV BC1	Nanograms per cubic meter (ng/m³) (Integer)	23201	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
UV BC2	Nanograms per cubic meter (ng/m³) (Integer)	24101	Calculated mass concentration for ultraviolet (UV) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
IR BC1	Nanograms per cubic meter (ng/m³) (Integer)	23958	Calculated mass concentration for infrared (IR) wavelength for sample spot sense1 in nanograms per cubic meter. Calculated in SingleSpot™ and DualSpot® sampling modes.
IR BC2	Nanograms per cubic meter (ng/m³) (Integer)	23745	Calculated mass concentration for infrared (IR) wavelength for sample spot sense2 in nanograms per cubic meter. Calculated in DualSpot® sampling mode.
CKSUM	Alphanumeric (XXX)	D39	

6.3. Status Codes

Code Value	Readable status	Status Description
1		No status notifications
2	Start up	Instrument in sampling and measurement startup
4	Tape advance	Tape advance occurring during sampling and measurement period
8		N/A
16	Optical saturation	Optical saturation
32	Sample timing error	Sample timing error
64		Sampling spot 2 of DualSpot® loading compensation is active
128	Flow unstable	Flow unstable during sampling and measurement period. Flow deviates from target flow setpoint by more than ±5%.
256	Pump drive limit	Flow out of range during sampling and measurement period
512	Time source manual	Time synchronization source is manual (synchronized to application/computer time or no GPS time is available)
1024	User skipped tape advance	User skipped tape advance. No tape advance occurred at start of sampling and measurements. NOT RECOMMENDED! SKIPPING THE AUTOMATIC TAPE ADVANCE AT THE BEGINNING OF SAMPLING AND MEASUREMENTS SHOULD ONLY BE USED WHEN GOOD DATA QUALITY IS NOT NEEDED.

If more than one status code is active simultaneously, the resulting code written to the data file is the sum of the error codes shown in the table above. For example, if the instrument is starting up (status code = 2) and the sampling spot 2 of DualSpot® loading compensation is active (status code = 64), the status code shown in the data file will be 66.

7. Maintenance and Service

7.1. Cleaning

If the microAeth is exposed to any liquids or other damaging contaminants, immediately turn off the instrument, disconnect all cables, and remove any foreign substances in contact with the instrument. Do not use liquids or other cleaning products on the instrument. Wait until the microAeth is completely dry before charging or turning on the instrument. Only AethLabs authorized service personnel should clean the air passageways and internal components of the microAeth. Keeping the microAeth and its air passageways, internal components, and optical chambers clean is critical for maintaining the instrument and producing quality measurements. Contamination of the instrument can cause increased measurement noise, poor sealing of the analytical area and degraded operational lifetime of some components. **AethLabs recommends sending your instrument for annual service, or more frequent service depending on use and operating conditions.**

7.2. Display and Check All Settings

The Display All Settings menu outputs all the current settings and status information of the microAeth via the 4-pin serial port to a terminal emulator (AethLabs only supports Tera Term for Windows) on a computer using the AethLabs 4-pin Serial to USB converter cable.

To view all settings, the on-board user interface on the front of the microAeth is used to send all settings information of the instrument which includes the flow calibration table (See section 5.8.3.11. Display All Settings).

Below are descriptions of all the settings and is an example of a settings table that will be displayed using the Display All Settings menu item. The values in the settings table can be analyzed and verified in order to determine the current state of the instrument.

7.2.1. Display All Settings Descriptions

The display all settings menu transmits via the serial port a complete summary of all settings and status of the microAeth.

Setting / Status	Format	Example	Description
Manufacturer	Alphanumeric	AethLabs	
Serial Number	Model and number (MAxxx-xxxx)	MA200-0011	Unique identification number for the Instrument.
Firmware Version	Decimal number	1.08	Unique identification number for firmware running on instrument when measurement was recorded.
Name	Alphanumeric	MA Device	User editable device name through microAeth Manager.
Timezone Offset	Minutes (Integer)	-480	Timezone offset from Coordinated Universal Time (UTC) in minutes.
Flow	Milliliters per minute (Whole number)	100	Target setpoint value of the instrument total flow rate in milliliters per minute. Used in SingleSpot™ and DualSpot® sampling modes.
Timebase	Seconds (Natural number)	60	Value in seconds of the measurement interval between measurements.
Tape Advance ATN	Attenuation units (Natural number, 1-100)	50	Tape advance ATN threshold value will trigger an automatic tape advance to a new filter sampling location during a sampling and measurement period. The attenuation (ATN) threshold value will trigger a tape advance when the first of the wavelength measurements reaches this threshold. NOTE: The lowest wavelength light source enabled will typically trigger the attenuation (ATN) tape advance.
Tape Advance Time		0 00:00:00.000Z	Not available in current firmware.
Tape Advance Intv	Two (2) Whole numbers	0 1	Not available in current firmware.
AutoSample	Whole number	0	Value of setting to automatically start sampling and measurements.
DualSpot	Whole number	1	DualSpot mode on or off.
GPS	Two (2) Whole numbers	1 1	Value of GPS setting.
GPS Time Sync	Whole number	1	GPS time sync on or off.
Bluetooth Enabled	Whole number	0	Not available in current firmware.
Serial Mode	Whole number	1	Value of serial mode.
Serial Format	Whole number	0	Value of serial format.
Serial Baud	Whole number with corresponding baud rate value	5 (1000000)	Value of serial baud rate.
Wavelengths	XX X X X XX	IR R G B UV	Identification of the optical wavelengths used for each measurement are displayed.
Spot2 Active		False	Current state of sample spot sense2.
Session Id	Whole number	54	Identification number assigned to each sampling and measurement session. This value is incremented each time a new sampling and measurement session is started (changes from STOPPED to SAMPLING mode).
(Next) Datum Id	Whole number	351055	ID of the next data line.
Datum Offset	Whole number	351055	ID of the first data line stored on the instrument.

Setting / Status	Format	Example	Description
Datum Size	Whole number	372	Length of each data line.
Tape At End	Whole number	0	Tape is a end.
Tape Error	Whole number	0	Tape error.
Tape Position	Whole number	1	Value of tape position counter. Increments by 1 after each tape advance. Counter is reset when 'Release Tape' is used to release the tape cartridge no matter the position of the newly inserted tape cartridge.
Tape Sample Time	Milliseconds (Whole number)	0	Length of time of sampling at current filter tape spot location.
Door State	Whole number	1	Not available in current firmware.
Battery Perc	Whole number	100	Percent of instrument internal battery remaining.
Battery Mean	Voltage (Whole number with 'V')	4.20V	Value of current voltage of battery.
Current	Current (Whole number with 'mA')	0mA	Not available in current firmware.
Baro Temperature	Degrees celsius (Decimal number)	19.37	Measured temperature inside instrument case in Celsius.
Baro Pressure	Pascals (Decimal number)	101512.00	Measured pressure inside instrument case in pascals.
Alt Resets	Whole number	1	Not available in current firmware
Humidity	Percent (Decimal number)	0.00	Measured relative humidity of instrument sampling stream in percent.
Temperature	Degrees celsius (Decimal number)	0.00	Measured temperature of instrument sampling stream in degrees celsius.
Acceleration	X <x.xxx> Y <y.yyy> Z <z.zzz>	X 5.466 Y -18.466 Z -277.333	Measured instantaneous acceleration in the x-axis, y-axis, and z-axis.
Satellites	Whole number	0	Number of satellites that are visible to the instrument's internal GPS receiver.
Latitude	Degrees (ddmm.mmmmm)	37.74619191	Measured latitude or relative angular distance north or south on Earth's surface in degrees from the equator.
Longitude	Degrees (dddmm.mmmmm)	-122.42032557	Measured longitude or relative angular distance east or west on Earth's surface in degrees from the prime meridian.
Speed	Kilometers per hour (Decimal number)	0.0000	Measured speed using GPS in kilometers per hour. GPS is based on GPS lat and long, which are required for GPS speed calculation.
RTC Time	Year, month, day, hours, minutes, seconds (yyyy/MM/dd hh:mm:ss)	18/11/21 01:17:29	Date and time of instrument's internal clock in Coordinated Universal Time (UTC).
Time Source	<GPS or Manual>	GPS	Time source is GPS or manual.
GPS Time	Year, month, day, hours, minutes, seconds (yyyy/MM/dd hh:mm:ss)	18/11/21 01:17:29	Date and time provided by GPS in Coordinated Universal Time (UTC).
WiFi	<OK or Not OK or Sleeping>	OK	Not available in current firmware.

Setting / Status	Format	Example	Description
Bluetooth	<OK or Not OK or Sleeping>	Not OK or Sleeping	Not available in current firmware.

7.2.2. Display All Settings Example

Settings	
Manufacturer:	AethLabs
Serial Number:	MA200-0011
Firmware Version:	1.08
Name:	MA Device
Timezone Offset:	-480
Flow:	100
Timebase:	60
Tape Advance ATN:	50
Tape Advance Time:	0 00:00:00.000Z
Tape Advance Intv:	0 1
AutoSample:	0
DualSpot:	1
GPS:	1 1
GPS Time Sync:	1
Bluetooth Enabled:	0
Serial Mode:	1
Serial Format:	0
Serial Baud:	5 (1000000)
Wavelengths:	IR R G B UV
Spot2 Active:	False
Session Id:	54
(Next) Datum Id:	351055
Datum Offset:	351055
Datum Size:	372
Tape At End:	0
Tape Error:	0
Tape Position:	1
Tape Sample Time:	0
Door State:	1
Battery Perc:	100
Battery Mean:	4.20V
Current:	0mA
Baro Temperature:	19.37
Baro Pressure:	101512.00
Alt Resets:	1
Humidity:	0.00
Temperature:	0.00
Acceleration:	X 5.466 Y -18.466 Z -277.333
Satellites:	0
Latitude:	37.74619191
Longitude:	-122.42032557
Speed:	0.0000
RTC Time:	18/11/21 01:17:29
Time Source:	GPS
GPS Time:	18/11/21 01:17:29
WiF:	OK
Bluetooth:	Not OK or Sleeping

FlowCal Table											
Device ID: MA200-0011											
Flow Meter Serial Number: 146654											
Timestamp: 2018-11-20T17:17:20.00											
Battery: 4.245V											
Sample temp: 22.51C											
Sample RH: 37.63%											
Internal pressure: 101536Pa											
SingleSpot Pump Start: 100											
SingleSpot Pump Stop: 12											
SingleSpot Flow Min: 19											
SingleSpot Flow Max: 281											
DualSpot Pump Start: 5											
DualSpot Pump Stop: 1											
DualSpot Flow Min: 21											
DualSpot Flow Max: 299											
-----SingleSpot Mode-----						-----DualSpot Mode-----					
#	TargetS	SFlowT	SFlow1	PumpS	SSD	TargetD	DFlowT	DFlow1	PumpD	DSD	S1/S2
0	0.00	124.99	124.03	0	0.00	0.00	124.90	123.90	0	0.01	0.00
1	43.93	180.30	179.20	69	2.04	45.75	181.79	164.51	49	2.46	1.41
2	58.82	197.69	197.76	88	1.65	58.74	197.48	175.92	65	1.82	1.42
3	74.38	215.58	216.97	112	1.21	74.90	215.49	190.49	87	1.48	1.41
4	89.79	231.66	235.80	140	0.94	90.07	231.28	203.94	111	1.21	1.41
5	104.83	245.98	253.85	170	0.78	105.09	245.39	217.09	139	0.99	1.41
6	120.17	259.53	271.43	203	0.60	120.35	258.28	229.99	169	0.86	1.41
7	135.40	272.50	288.69	238	0.53	135.78	271.66	243.48	201	0.68	1.41
8	149.71	283.43	304.11	273	0.45	150.28	282.74	255.69	233	0.60	1.41
9	164.67	293.83	319.65	315	0.37	164.56	293.13	267.65	267	0.51	1.40
10	179.39	303.29	334.45	360	0.31	179.79	303.28	280.27	306	0.42	1.40
11	194.06	310.21	348.08	409	0.25	194.67	311.80	292.35	348	0.37	1.40
12	209.38	319.61	362.21	469	0.22	209.56	321.00	303.94	396	0.33	1.40
13	223.92	327.67	375.51	535	0.19	224.24	329.85	315.56	450	0.26	1.39
14	238.91	334.19	388.55	617	0.17	239.08	338.19	326.65	512	0.22	1.39
15	253.92	340.43	401.32	728	0.14	253.44	343.88	337.23	584	0.24	1.38
16	269.59	344.87	413.57	843	0.21	268.32	349.48	348.23	680	0.20	1.38
17	0.00	0.00	0.00	0	0.00	283.32	357.21	359.09	789	0.14	1.37
18	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
19	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
20	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
21	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
FlowCal Results: OK 35/35											

X0	1240	1800	846723	0.00018
X1	1210	4800	770326	0.00022
X2	1230	3300	697348	0.00026
X3	1340	1500	957703	0.00022
X4	1280	8400	902555	0.00020

7.3. Flow Calibration

7.3.1. Flow Calibration Table

The flow calibration table stored in the microAeth is used to control and measure the instrument's flow system. The instrument's internal flow sensors and pump are calibrated to an accurate flow rate for each setpoint in the flow calibration table using an external mass flowmeter as a reference standard. Parameters of the environment, microAeth, and external flowmeter from the MA Series Flow Calibration Kit used to calibrate the microAeth are also stored as part of the header of the flow calibration table.

Many commercial flowmeters are mass flowmeters. They calculate a flow rate by measuring the amount of gas molecules (or mass of the gas) moving through the device during a certain amount of time. However, because we commonly measure gases such as air as the volumes they occupy (as cc's or liters, for instance), usually at standard atmospheric pressure and temperature, flowmeters most often report flow rates not as a mass unit over time, but as a volume unit over time. The internal flow sensors are also measuring mass flow and converting these values to volumetric values using the flow calibration table. **Only the external mass flowmeter in the AethLabs MA Series Flow Calibration Kit is compatible with the MA200, MA300, and MA350.** The external flowmeter in the microAeth MA Series Flow Calibration Kit is a custom unit made for AethLabs specifically for the microAeth MA Series instruments to optimize the measurement flow range for the low flow and low back pressure requirements. The flow calibration process requires multiple calibration passes and the calibration of multiple flowmeters with multiple solenoid switches as well as other process controls. The process must be automated and thus the microAeth firmware has been developed to work with a specific custom flowmeter.

Other flowmeters may not be suitable for use with the MA Series instruments for a few reasons. (1) Other flowmeters with wider flow measurement ranges may only have one or two calibration setpoints in the full range of the MA Series instruments. (2) Many ΔP based flowmeters have higher backpressure, and as such, very little flow will be drawn through the instrument. (3) Bubble meters are far too slow to be used with the MA Series instruments in the required automated flow calibration process. (4) The flow calibration of MA Series instruments must be automated because the process is complicated with multiple solenoid switches and a high possibility for human error, therefore it requires a direct communication interface with the external flowmeter.

7.3.2. Display and Check Flow Calibration Table

The flow calibration table stored in the microAeth can be viewed in order to verify that a good, complete flow calibration table exists. A good, complete flow calibration table is critical in order to obtain the best results from the microAeth.

To view the flow calibration table and the complete results from the previous flow calibration, the on-board user interface on the front of the microAeth is used to send all settings information of the instrument which includes the flow calibration table (See section 5.8.3.11 Display All Settings) or just the flow calibration table information (See section 5.8.3.12. Display FlowCal Info) via the 4-pin serial port to a terminal emulator (AethLabs only supports Tera Term for Windows) on a computer using the AethLabs 4-pin Serial to USB converter cable.

7.3.2.1. Flow Calibration Table Results Descriptions

The flow calibration table shows a summary of the final results of the current flow calibration. Below the flow calibration table itself is the text 'FlowCal Results:' after which the detailed summary results are displayed. At the completion of a flow calibration, the same abbreviated results shown in the 'Result' column of the below table are displayed on the LCD screen. If results other than 'OK <yy/yy>' are displayed then another flow calibration should be run. **It can take multiple flow calibration attempts to achieve the best calibration.**

FlowCal Results	
Result	Description
OK <yy/yy>	Flow calibration completed successfully. A complete table without warnings or failures occurred. 'yy' equals the amount of flow calibration setpoints that were calibrated. yy/yy = 100% (Example: OK 35/35)
WARNING <xx/yy>	Flow calibration completed successfully but with warnings to review. 'Review rows marked with *' will be displayed below 'FlowCal Results: WARNING <xx/yy>' and all flow calibration setpoints that have possible issues are marked with '*'. xx/yy < 100% (Example: WARNING 34/35)
FAIL MIN <xx/yy>	Flow calibration completed but with failure to reach minimum flow rate in SingleSpot™ and or DualSpot®. 'Min Flow of 40 Not Achieved in <SingleSpot or DualSpot> Mode (<actual minimum flow>)' will be displayed below 'FlowCal Results: FAIL MIN <xx/yy>' where xx/yy <= 100%. If xx/yy < 100%, then 'Review rows marked with *' will also be displayed and all flow calibration setpoints that have possible issues are marked with '*'.
FAIL MAX <xx/yy>	Flow calibration completed but with failure to reach maximum flow rate in SingleSpot™ and or DualSpot®. 'Max Flow of 182 Not Achieved in <SingleSpot or DualSpot> Mode (<actual maximum flow>)' will be displayed below 'FlowCal Results: FAIL MAX <xx/yy>' where xx/yy <= 100%. If xx/yy < 100%, then 'Review rows marked with *' will also be displayed and all flow calibration setpoints that have possible issues are marked with '*'.
FAIL MIN MAX <xx/yy>	Flow calibration completed but with failure to reach minimum and maximum flow rates in SingleSpot™ and or DualSpot®. Both 'Min Flow of 40 Not Achieved in <SingleSpot or DualSpot> Mode (<actual minimum flow>)' and 'Max Flow of 182 Not Achieved in <SingleSpot or DualSpot> Mode (<actual maximum flow>)' will be displayed below 'FlowCal Results: FAIL MAX <xx/yy>' where xx/yy <= 100%. If xx/yy < 100%, then 'Review rows marked with *' will also be displayed and all flow calibration setpoints that have possible issues are marked with '*'.

7.3.2.2. Flow Calibration Table Example

Below is an example of a flow calibration table that will be displayed using the Display All Settings or Display FlowCal Info menu items. The values in the flow calibration table can be analyzed and verified in order to determine if another flow calibration is required. If multiple flow calibrations have been performed and still there are issues, please contact AethLabs.

FlowCal Table											
Device ID: MA200-0011											
Flow Meter Serial Number: 146654											
Timestamp: 2018-11-20T17:17:20.00											
Battery: 4.245V											
Sample temp: 22.51C											
Sample RH: 37.63%											
Internal pressure: 101536Pa											
SingleSpot Pump Start: 100											
SingleSpot Pump Stop: 12											
SingleSpot Flow Min: 19											
SingleSpot Flow Max: 281											
DualSpot Pump Start: 5											
DualSpot Pump Stop: 1											
DualSpot Flow Min: 21											
DualSpot Flow Max: 299											
-----SingleSpot Mode-----						-----DualSpot Mode-----					
#	TargetS	SFlowT	SFlow1	PumpS	SSD	TargetD	DFlowT	DFlow1	PumpD	DSD	S1/S2
0	0.00	124.99	124.03	0	0.00	0.00	124.90	123.90	0	0.01	0.00
1	43.93	180.30	179.20	69	2.04	45.75	181.79	164.51	49	2.46	1.41
2	58.82	197.69	197.76	88	1.65	58.74	197.48	175.92	65	1.82	1.42
3	74.38	215.58	216.97	112	1.21	74.90	215.49	190.49	87	1.48	1.41
4	89.79	231.66	235.80	140	0.94	90.07	231.28	203.94	111	1.21	1.41
5	104.83	245.98	253.85	170	0.78	105.09	245.39	217.09	139	0.99	1.41
6	120.17	259.53	271.43	203	0.60	120.35	258.28	229.99	169	0.86	1.41
7	135.40	272.50	288.69	238	0.53	135.78	271.66	243.48	201	0.68	1.41
8	149.71	283.43	304.11	273	0.45	150.28	282.74	255.69	233	0.60	1.41
9	164.67	293.83	319.65	315	0.37	164.56	293.13	267.65	267	0.51	1.40
10	179.39	303.29	334.45	360	0.31	179.79	303.28	280.27	306	0.42	1.40
11	194.06	310.21	348.08	409	0.25	194.67	311.80	292.35	348	0.37	1.40
12	209.38	319.61	362.21	469	0.22	209.56	321.00	303.94	396	0.33	1.40
13	223.92	327.67	375.51	535	0.19	224.24	329.85	315.56	450	0.26	1.39
14	238.91	334.19	388.55	617	0.17	239.08	338.19	326.65	512	0.22	1.39
15	253.92	340.43	401.32	728	0.14	253.44	343.88	337.23	584	0.24	1.38
16	269.59	344.87	413.57	843	0.21	268.32	349.48	348.23	680	0.20	1.38
17	0.00	0.00	0.00	0	0.00	283.32	357.21	359.09	789	0.14	1.37
18	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
19	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
20	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
21	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0	0.00	0.00
FlowCal Results: OK 35/35											

7.3.3. Test Flow Procedure

The on-board user interface on the front of the microAeth can be used to test flow setpoints and see what the internal flowmeters are reading in DualSpot or SingleSpot mode. Please note that the external flowmeter of the microAeth MA Series Flow Calibration Kit or other low backpressure external flowmeter is not needed to use this feature but is needed to verify the internal measured flow readings against an external standard.

- 1) If checking the internal measured flow of the microAeth to an external standard, connect the outlet port of the external flowmeter to the inlet port of the microAeth.
- 2) Make sure that all connections are tight and sealed so that no leaks are present.
- 3) Use the left and right buttons of the microAeth to scroll through the top level menu options to the 'Test Flow' option.
- 4) Press the center button of the microAeth to select the 'Test Flow' option.
- 5) Use the left and right buttons of the microAeth to scroll to the desired target flow of 50, 75, 100, 125, or 150 ml/min. The screen will display the following depending if the microAeth is in SingleSpot or DualSpot mode:

SingleSpot Mode Test Flow Display		DualSpot Mode Test Flow Display	
SS Target	xxx.xx	DS Target	xxx.xx
SS Measured	xxx.xx	DS Measured	xxx.xx

NOTE: To use the test flow feature in the desired SingleSpot or DualSpot mode, this sampling mode setting must first be changed using the microAeth Manager software connected to the microAeth by USB.

- 6) Use the left and right buttons to change the target flow at any time. Allow the microAeth a few seconds to adjust pump speed and for the flow to become stable.
- 7) The measured flow can be viewed over time as there will be fluctuations. The measured flow can also be compared against the external flowmeter of the MA Series Flow calibration Kit that has its outlet port connected to the inlet port of the microAeth. Only compatible low backpressure external flowmeters should be used.
- 8) Press the center button to exit the test flow feature.

7.3.4. Flow Calibration Kit Setup

The only way to perform a flow calibration of the MA200, MA300, and MA350 is to use a microAeth MA Series Flow Calibration Kit provided by AethLabs.

It is recommended that all microAeth MA Series Flow Calibration Kits use the provided low backpressure inline disc filter on the inlet of the external flowmeter to keep the external flowmeter clean and to keep the microAeth sampling filter clean during flow calibration. An inline filter isn't required but is recommended especially if a flow calibration is being completed outdoors or in a dirty environment.

Flow Connections: **The inlet port of the microAeth MA Series instrument must be connected to the outlet port of the external flowmeter of the microAeth MA Series Flow Calibration Kit.** The arrow on the front of the external flowmeter shows the air flow direction with the point of the arrow being the outlet port and the opposite being the inlet port. The inlet port of the external flowmeter should be connected to the low backpressure inline disc filter.

Communication Connections: The microAeth MA Series Flow Kit communication cable must be connected to the microAeth serial port and the external flowmeter mini-din 8 port.

Power Connections: The microAeth should be connected to an external power source through the barrel jack port labeled 'DC IN (5V)'. The external flowmeter must be connected to an external power source through the barrel jack.

NOTE: The microAeth internal battery should be fully charged (recommended battery remaining of at least 80%).

External Flowmeter Settings: The microAeth MA Series instruments will automatically set all settings on the external flowmeter at the start of the flow calibration process. It is not recommended to change the settings of the external flowmeter. The required settings of the external flowmeter for the flow calibration process are as follows:

microAeth MA Series Flow Calibration Kit External Flowmeter	
Setting	Value
Communication Baud Rate:	57600
Unit ID:	A
Gas:	Air
Volumetric Flow Units:	milliliters per minute (ml/m)
Mass Flow Units:	milliliters per minute (Sml/m)
Flow Averaging:	255
Pressure Averaging:	255
Standard Temperature:	25.00 °C
Standard Pressure:	14.70 PSIA
Normal Temperature:	0.00 °C
Normal Pressure:	14.70 PSIA

7.3.5. Flow Calibration Procedure

The on-board user interface on the front of the microAeth can be used to start the automatic flow calibration process. Please note that the flow calibration must calibrate two flowmeters and therefore similar information may be displayed on screen during the calibration of flowmeter one and two.

IMPORTANT: Before starting the automatic flow calibration process, the filter tape cartridge must be at a new clean filter sampling location. The microAeth should be plugged into an external power source and its internal battery should be fully charged (recommended battery remaining of at least 80%). The only way to perform a flow calibration on the MA200, MA300, and MA350 is to use a microAeth MA Series Flow Calibration Kit provided by AethLabs.

- 1) The microAeth must be at a new clean filter sampling location for the flow calibration.
- 2) If the microAeth is not already at a new clean filter sampling location, use the left and right buttons to scroll through the top level menu options to the 'Advance Tape' option. Otherwise skip to step 4.
- 3) Press the center button to select the 'Advance Tape' option. The microAeth will advance the filter tape cartridge to a new clean filter sampling location.
- 4) Plug in the microAeth to an external power source through the barrel jack port.
- 5) Plug in the MA Series Flow Calibration Kit flowmeter to an external power source. Make sure the flowmeter is turned on.
- 6) Connect the MA Series Flow Calibration Kit communication cable to the microAeth serial port and the flowmeter mini-din 8 port.
- 7) Connect the outlet port of the MA Series Flow Calibration Kit flowmeter to the inlet port of the microAeth.
- 8) Make sure that all connections are tight and sealed so that no leaks are present.
- 9) Use the left and right buttons of the microAeth to scroll through the top level menu options to the 'Calibrate Flow' option.
- 10) Press the center button of the microAeth to select the 'Calibrate Flow' option. The screen will display 'FLOW CALIBRATE Switch to CAL CABLE. Press any button.'
- 11) Press any button to start the automatic flow calibration of the microAeth.
- 12) The microAeth will check flow and communications.
- 13) The screen will display 'Highest Flow'
- 14) If there is a communications issue, the screen will display 'NO COMMS DETECTED'. The screen will then display 'FLOWCAL - NO COMMS Switch to REG CABLE Press any button'. Press any button to return to the top level menu and return to step 3.
- 15) If there is a flow issue, the screen will display 'NO FLOW DETECTED'. The screen will then display 'FLOWCAL - NO FLOW Switch to REG CABLE Press any button'. Press any button to return to the top level menu and return to step 3.
- 16) If there are no issues, the screen will display the max flow that can be reached and will then begin the flow calibration.
- 17) To cancel the flow calibration at any point, press the center button. The screen will quickly display 'Flow Cal Stopping'. The screen will then display 'FLOWCAL - CANCEL Switch to REG CABLE Press any button'. Press any button to return to the top level menu.
- 18) When the automatic flow calibration is complete, the screen will display 'FLOWCAL - OK xx/xx Switch to REG CABLE Press any button' Press any button to return to the top level menu.
- 19) Disconnect the MA Series Flow Calibration Kit communication cable from the microAeth.
- 20) Disconnect the MA Series Flow Calibration Kit flowmeter from the inlet port of the microAeth.
- 21) Check the microAeth flow calibration table to verify that a good calibration was completed. Not every

flow calibration process will produce the desired flow calibration table. See section 7.3.2. Display and Check Flow Calibration Table.

7.4. Optical Calibration Procedure

The on-board user interface on the front of the microAeth can be used to start the automatic optical calibration process.

IMPORTANT: OPTICAL CALIBRATIONS ARE NOT RECOMMENDED UNLESS INSTRUCTED TO DO SO BY AETHLABS OR AETHLABS AUTHORIZED SERVICE PERSONNEL. Before starting the automatic optical calibration process, the filter tape cartridge must be at a new clean filter sampling location. The microAeth should be plugged into an external power source. The optical calibration should be run only when the filter tape cartridge door is installed and closed. The optical calibration CANNOT be cancelled once it is started.

- 1) The microAeth must be at a new clean filter sampling location for the optical calibration.
- 2) If the microAeth is not already at a new clean filter sampling location, use the left and right buttons to scroll through the top level menu options to the 'Advance Tape' option. Otherwise skip to step 4.
- 3) Press the center button to select the 'Advance Tape' option. The microAeth will advance the filter tape cartridge to a new clean filter sampling location.
- 4) Plug in the microAeth to an external power source through the barrel jack port.
- 5) Make sure the filter tape cartridge door is installed and closed.
- 6) Use the left and right buttons of the microAeth to scroll through the top level menu options to the 'Calibrate Optics' option.
- 7) Press the center button of the microAeth to select the 'Calibrate Optics' option and to enter the calibrate optics submenu. 'YES OK NO' will be displayed.
- 8) Press the center button to exit and return to the top level menu.
- 9) Press the left button 'YES' and the screen will display 'Calibrate? YES'. Press the right button 'NO' and the screen will display 'Calibrate? NO'.
- 10) Press the center button, 'OK' to select the current yes or no value option. Once selected, the optical calibration will start and 'Starting' will be displayed.
- 11) As the optical calibration progresses, the screen will display 'Calibrating... xxxx' and the 'xxxx' four digit numbers will be updated.
- 12) When the optical calibration is complete, 'Calibration Complete' will be displayed and the user interface menu is automatically returned to the top menu level.

7.5. Installing Operating System Firmware

The on-board user interface on the front of the microAeth can be used to upgrade the operating system firmware via the 4-pin serial port. Upgrading the operating system firmware of the microAeth can be accomplished through a terminal emulator using the AethLabs 4-pin Serial to USB converter cable.

Before using the AethLabs 4-pin Serial to USB converter cable, it may be required to install drivers from Future Technology Devices International Ltd. (FTDI) in order for the converter cable to be recognized by and used with the computer.

7.5.1. Upgrading firmware from version 1.05 to 1.08

IMPORTANT READ FIRST: ALL DATA ON THE MICROAETH WILL NOT BE ACCESSIBLE AFTER UPGRADING FIRMWARE. All memory on the microAeth will need to be erased after upgrading the firmware. Before upgrading the firmware on the microAeth, download and backup all data from the instrument. A flow calibration and optical calibration may be required after upgrading the firmware.

Make sure that you have a microAeth MA Series Flow Calibration Kit provided by AethLabs as this is the only way to perform a flow calibration on the MA200, MA300, and MA350.

- 1) Unplug the microAeth from all external power sources.
- 2) Plug in the AethLabs Serial to USB converter cable to the 4-pin serial port of the microAeth. Plug in the USB A plug of the cable into a computer where data will be download.
- 3) Open a terminal emulator (AethLabs only supports Tera Term for Windows) on the computer and use the following settings (as described in section 5.5.3):

Baud Rate	Data	Parity	Stop	Flow control
1000000	8 bit	none	1 bit	Xon/Xoff

- 4) When Tera Term opens, a window with the title 'Tera Term: New connection' will appear.
- 5) Select the 'Serial' radio button.
- 6) Use the 'Port:' dropdown menu to select the COM port that the microAeth is connected to through the AethLabs 4-pin Serial to USB converter cable.
- 7) Press 'OK'.
- 8) The main window will remain and the window title will now be the COM port number.
- 9) Select the 'Setup' menu and select 'Serial port...'
- 10) In the 'Tera Term: Serial port setup' window, change the settings to match the communication settings in Step 3.
- 11) Press 'OK'.
- 12) The terminal emulator should now display the on-board user interface options as the 3 button interface is used by the user. More information that is hidden on the microAeth on-board screen will be displayed in the terminal emulator.
- 13) Use the left and right buttons to scroll through the top level menu options to the 'Turn off' option.
- 14) Press the center button to select the 'Turn off' option.
- 15) While the microAeth is off, press and hold both the left and right buttons at the same time for about 2 seconds.
- 16) If successful in entering the bootloader, the screen backlight will flash on three times and stay on.
- 17) The microAeth will display more information to the terminal emulator.

- 18) 'Serial Decrypting Bootloader Version x.xxL Serial Number [MAxxx-xxxx] - xxxx' will then be displayed.
- 19) If unsuccessful in entering the bootloader, the microAeth will turn off and nothing more will be displayed. To try again, make sure the microAeth is off and repeat steps 1-15
- 20) Follow the instructions displayed in the terminal emulator and bootloader to upgrade the firmware. 'Press CENTER button to start bootlad process, Press LEFT or RIGHT buttons to CANCEL' will be displayed.
- 21) Once entering the bootloader, you will have 30 seconds to make a selection before the microAeth automatically turns off. If this occurs, 'Timeout. Shutting Down' will be displayed.
- 22) Press either the left or right buttons to exit the bootloader and cancel the bootload process. 'Cancelled' will be displayed and the microAeth will shut off.
- 23) Press the center button to start the bootloader firmware upgrade process. More information and 'Waiting for download... (you have 30s)' will be display. The microAeth will wait 30 seconds for the user to send the firmware data file to the microAeth through the terminal emulator. If a file is not sent to the microAeth, the instrument will timeout, display 'LOAD BAD' and shut down. If this occurs, the microAeth will no longer have a valid firmware loaded. Any time the instrument is turned on again, only the bootloader will start.
- 24) To send a file to the microAeth through Tera Term. Select the 'File' menu and select 'Send file...'
- 25) The 'Tera Term: Send file' window will open. Select the firmware '.hex' file.
- 26) Press 'Open'.
- 27) Transfer will begin immediately and if the transfer successfully initiated, "*" star symbols will be displayed as the transfer progresses. Do not interrupt the data transfer and upgrade. Wait until the process is fully complete and 'SUCCESS' is displayed.
- 28) If the firmware transfer and upgrade fails, 'BAD LOAD' will be displayed. The microAeth will no longer have a valid firmware loaded. Any time the instrument is turned on again, only the bootloader will start.
- 29) If the firmware transfer and upgrade are successful, the data transfer will finish, 'GOOD LOAD' will be displayed, self-checks will complete, 'SUCCESS' and 'Shut Down' will be displayed, and the microAeth will shut down. Once the screen backlight turns off, the firmware upgrade is complete.
- 30) The operating system firmware is upgraded on the microAeth but more steps are required in order for the microAeth to be able to function properly for sampling and make measurements.**
- 31) Turn on the microAeth. Press and hold only one of the three buttons for 2 seconds. The screen and instrument will turn on and the instrument serial number will be displayed.
- 32) A flow calibration is now required. Please follow the steps in section 7.3. Flow Calibration Procedure
- 33) An optical calibration is now required. Please follow the steps in section 7.4. Optical Calibration Procedure
- 34) Turn the microAeth off by using the left and right buttons to scroll through the top level menu options to the 'Turn off' option.
- 35) Press the center button to select the 'Turn off' option.
- 36) The memory on microAeth must be erased. All data must be deleted. Please follow the steps in section 5.7.7. Delete All Data on the microAeth to erase the memory.
- 37) Set all settings using the microAeth Manager.

7.5.2. Upgrading firmware from version 1.07 to 1.08

IMPORTANT READ FIRST: DATA ON THE MICROAETH MAY NOT BE ACCESSIBLE AFTER UPGRADING FIRMWARE. Before upgrading the firmware on the microAeth, download and backup all data from the instrument.

- 1) Unplug the microAeth from all external power sources.
- 2) Plug in the AethLabs Serial to USB converter cable to the 4-pin serial port of the microAeth. Plug in the USB A plug of the cable into a computer where data will be download.
- 3) Open a terminal emulator (AethLabs only supports Tera Term for Windows) on the computer and use the following settings (as described in section 5.5.3):

Baud Rate	Data	Parity	Stop	Flow control
1000000	8 bit	none	1 bit	Xon/Xoff

- 4) When Tera Term opens, a window with the title 'Tera Term: New connection' will appear.
- 5) Select the 'Serial' radio button.
- 6) Use the 'Port:' dropdown menu to select the COM port that the microAeth is connected to through the AethLabs 4-pin Serial to USB converter cable.
- 7) Press 'OK'.
- 8) The main window will remain and the window title will now be the COM port number.
- 9) Select the 'Setup' menu and select 'Serial port...'
- 10) In the 'Tera Term: Serial port setup' window, change the settings to match the communication settings in Step 3.
- 11) Press 'OK'.
- 12) The terminal emulator should now display the on-board user interface options as the 3 button interface is used by the user. More information that is hidden on the microAeth on-board screen will be displayed in the terminal emulator.
- 13) Use the left and right buttons to scroll through the top level menu options to the 'Turn off' option.
- 14) Press the center button to select the 'Turn off' option.
- 15) While the microAeth is off, press and hold both the left and right buttons at the same time for about 2 seconds.
- 16) If successful in entering the bootloader, the screen backlight will flash on three times and stay on.
- 17) The microAeth will display more information to the terminal emulator.
- 18) 'Serial Decrypting Bootloader Version x.xxL Serial Number [MAxxx-xxxx] - xxxx' will then be displayed.
- 19) If unsuccessful in entering the bootloader, the microAeth will turn off and nothing more will be displayed. To try again, make sure the microAeth is off and repeat steps 1-15
- 20) Follow the instructions displayed in the terminal emulator and bootloader to upgrade the firmware. 'Press CENTER button to start bootlad process, Press LEFT or RIGHT buttons to CANCEL' will be displayed.
- 21) Once entering the bootloader, you will have 30 seconds to make a selection before the microAeth automatically turns off. If this occurs, 'Timeout. Shutting Down' will be displayed.
- 22) Press either the left or right buttons to exit the bootloader and cancel the bootload process. 'Cancelled' will be displayed and the microAeth will shut off.
- 23) Press the center button to start the bootloader firmware upgrade process. More information and 'Waiting for download... (you have 30s)' will be display. The microAeth will wait 30 seconds for the user to send the firmware data file to the microAeth through the terminal emulator. If a file is not sent to the microAeth, the instrument will timeout, display 'LOAD BAD' and shut down. If this occurs, the microAeth will

no longer have a valid firmware loaded. Any time the instrument is turned on again, only the bootloader will start.

24) To send a file to the microAeth through Tera Term. Select the 'File' menu and select 'Send file...'

25) The 'Tera Term: Send file' window will open. Select the firmware '.hex' file.

26) Press 'Open'.

27) Transfer will begin immediately and if the transfer successfully initiated, '*' star symbols will be displayed as the transfer progresses. Do not interrupt the data transfer and upgrade. Wait until the process is fully complete and 'SUCCESS' is displayed.

28) If the firmware transfer and upgrade fails, 'BAD LOAD' will be displayed. The microAeth will no longer have a valid firmware loaded. Any time the instrument is turned on again, only the bootloader will start.

29) If the firmware transfer and upgrade are successful, the data transfer will finish, 'GOOD LOAD' will be displayed, self-checks will complete, 'SUCCESS' and 'Shut Down' will be displayed, and the microAeth will shut down. Once the screen backlight turns off, the firmware upgrade is complete.

30) The operating system firmware is upgraded on the microAeth but the flow calibration table should be checked and all settings should be set.

31) Turn on the microAeth. Press and hold only one of the three buttons for 2 seconds. The screen and instrument will turn on and the instrument serial number will be displayed.

32) Use the left and right buttons to scroll through the top level menu options to the 'Display FlowCal Info' option.

33) 'Sent via Serial Port' will display on the screen and the flow calibration table information will be displayed in the terminal emulator. See section 5.8.3.12. Display FlowCal Info for more information.

34) Check the flow calibration table. See section 7.3.2. Display and Check Flow Calibration Table.

35) Set all settings using the microAeth Manager.

8. Technical Specifications

8.1. MA200

Measurement method

Real-time, 5 wavelength spectrum analysis by measuring the rate of change of transmitted light due to continuous particle deposition on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ('BC'). Measurement at 375 nm interpreted as Ultraviolet Particulate Matter ('UVPM') indicative of woodsmoke, tobacco, and biomass burning.

Measurement Wavelengths

880 nm, 625 nm, 528 nm, 470 nm, 375 nm

DualSpot® Loading Compensation

Real-time analysis by measuring the rate of change in absorption of transmitted light due to the continuous collection of aerosol on filter. Simultaneous collection on two spots in parallel at different flow rates.

Timebases

1, 5, 10, 30, 60, or 300 seconds

Flow Rates

Internal pump provides 50, 75, 100, 125 or 150 ml/min, DualSpot® compensation not compatible with all settings

Measurement Range

Per sampling location, 0-1 mg BC/m³, filter sampling location lifetime dependent on concentration and flow rate setting, decreasing proportionally with lowest wavelength optical source enabled:
IR only mode, average 5 µg BC/m³ for 24 hours at 100 ml/min
IR only mode, average 100 µg BC/m³ for 3 hours at 50 ml/min
IR only mode, average 1 mg BC/m³ for 15 minutes at 50 ml/min

Measurement Resolution

0.001 µg BC/m³

Limit of Detection

30 ng BC/m³, 5 min timebase., 150 ml/min flow rate, SingleSpot™

Pump Options

Standard internal diaphragm pump, Optional internal rotary vane pump

Flow Control

Internal mass flowmeters with closed-loop control

Filter Material / Capacity

MA200 Filter Tape Cartridge with Polytetrafluoroethylene (PTFE) material (15 sampling locations)

Sampling

3 mm diameter spot(s) created on filter tape. User selectable DualSpot® or SingleSpot™ mode.

Environmental Sensors

Accelerometer, Relative Humidity, Temperature, Altimeter/Barometer

Dimensions

L: 136.75 mm (5.38 in), W: 85 mm (3.35 in), D: 35.75 mm (1.41 in)

Weight

420 grams (14.82 ounces)

Memory

16GB internal flash memory, providing storage for 31,250,000 data lines; 1 second timebase: 361 days of data

On-board Interface

Low Power Screen, 3 Buttons

Location services

GPS with Internal Antenna

Date/Time Format

ISO 8601 with satellite synchronization or manual computer synchronization

Wireless

802.11 b/g/n Wi-Fi with AES hardware encryption, Bluetooth Low Energy. Available in future firmware releases.

Connections

USB 2.0, 3.3V TTL Serial, DC input via barrel jack, Aerosol sample inlet and outlet ports

USB Communication / Client Application

USB connectivity to cross-platform microAeth® Manager software available on macOS® and Windows®. microAeth Manager software is included and facilitates settings configuration and data download. Exported data can be uploaded to AethLabs Dashboard server for processing and visualization.

Serial Communication

3.3V TTL serial connectivity for uploading new instrument firmware, flow calibration, streaming data and polling protocols to request data, modify settings and control. Command line interface (CLI) polling protocols: AethLabs protocol and Bayern-Hessen protocol.

Total Run Time

Up to 14 hours at 60 second timebase, 100 ml/min flow rate on single battery charge. Run time may vary due to PM concentrations and settings.

Battery

Internal 3.6V, 3200 mAh (11.52 Wh), 1 cell rechargeable lithium-ion battery

Charging

Fast charging DC via barrel jack AC adapter (~3 hours to full charge, instrument turned off) or USB charging (~6.5 hours to full charge, instrument turned off)
Power Supply Adapter: Input: 100~240 VAC 50/60Hz 0.4A, Output: 5VDC / 2A, with option for Type A, C, G, or I plug

Operating Environment

5 ~ 40 °C operating, non-condensing.

Specifications are subject to change without notice.

8.2. MA300

Measurement method

Real-time, 5 wavelength spectrum analysis by measuring the rate of change of transmitted light due to continuous particle deposition on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ('BC'). Measurement at 375 nm interpreted as Ultraviolet Particulate Matter ('UVP') indicative of woodsmoke, tobacco, and biomass burning.

Measurement Wavelengths

880 nm, 625 nm, 528 nm, 470 nm, 375 nm

DualSpot® Loading Compensation

Real-time analysis by measuring the rate of change in absorption of transmitted light due to the continuous collection of aerosol on filter. Simultaneous collection on two spots in parallel at different flow rates.

Timebases

1, 5, 10, 30, 60, or 300 seconds

Flow Rates

Internal pump provides 50, 75, 100, 125 or 150 ml/min, DualSpot® compensation not compatible with all settings

Measurement Range

Per sampling location, 0-1 mg BC/m³, filter sampling location lifetime dependent on concentration and flow rate setting, decreasing proportionally with lowest wavelength optical source enabled:
IR only mode, average 5 µg BC/m³ for 24 hours at 100 ml/min
IR only mode, average 100 µg BC/m³ for 3 hours at 50 ml/min
IR only mode, average 1 mg BC/m³ for 15 minutes at 50 ml/min

Measurement Resolution

0.001 µg BC/m³

Limit of Detection

30 ng BC/m³, 5 min timebase., 150 ml/min flow rate, SingleSpot™

Pump Options

Standard internal diaphragm pump, Optional internal rotary vane pump

Flow Control

Internal mass flowmeters with closed-loop control

Filter Material / Capacity

MA300/350 Filter Tape Cartridge with Polytetrafluoroethylene (PTFE) material (85 sampling locations)

Sampling

3 mm diameter spot(s) created on filter tape. User selectable DualSpot® or SingleSpot™ mode.

Environmental Sensors

Accelerometer, Relative Humidity, Temperature, Altimeter/Barometer

Dimensions

L: 165.20 mm (6.50 in), W: 125.20 mm (4.93 in), D: 39.70 mm (1.56 in)

Weight

715 grams (25.22 ounces)

Memory

16GB internal flash memory, providing storage for 31,250,000 data lines; 1 second timebase: 361 days of data

On-board Interface

Low Power Screen, 3 Buttons

Location Services

GPS with Internal Antenna

Date/Time Format

ISO 8601 with satellite synchronization or manual computer synchronization

Wireless

802.11 b/g/n Wi-Fi with AES hardware encryption, Bluetooth Low Energy. Available in future firmware releases.

Connections

USB 2.0, 3.3V TTL Serial, DC input via barrel jack, Aerosol sample inlet and outlet ports

USB Communication / Client Application

USB connectivity to cross-platform microAeth® Manager software available on macOS® and Windows®. microAeth Manager software is included and facilitates settings configuration and data download. Exported data can be uploaded to AethLabs Dashboard server for processing and visualization.

Serial Communication

3.3V TTL serial connectivity for uploading new instrument firmware, flow calibration, streaming data and polling protocols to request data, modify settings and control. Command line interface (CLI) polling protocols: AethLabs protocol and Bayern-Hessen protocol.

Total Run Time

Up to 56 hours at 60 second timebase, 100 ml/min flow rate on single battery charge. Run time may vary due to PM concentrations and settings.

Battery

Internal 3.6V, 12800 mAh (46.08 Wh), 4 cell rechargeable lithium-ion battery

Charging

Fast charging DC via barrel jack AC adapter (~11.75 hours to full charge, instrument turned off) or USB charging (~25.75 hours to full charge, instrument turned off)
Power Supply Adapter: Input: 100~240 VAC 50/60Hz 0.4A, Output: 5VDC / 2A, with option for Type A, C, G, or I plug

Operating Environment

5 ~ 40 °C operating, non-condensing.

Specifications are subject to change without notice.

8.3. MA350

Measurement method

Real-time, 5 wavelength spectrum analysis by measuring the rate of change of transmitted light due to continuous particle deposition on filter. Measurement at 880 nm interpreted as concentration of Black Carbon ('BC'). Measurement at 375 nm interpreted as Ultraviolet Particulate Matter ('UVP') indicative of woodsmoke, tobacco, and biomass burning.

Measurement wavelengths

880 nm, 625 nm, 528 nm, 470 nm, 375 nm

DualSpot® Loading Compensation

Real-time analysis by measuring the rate of change in absorption of transmitted light due to the continuous collection of aerosol on filter. Simultaneous collection on two spots in parallel at different flow rates.

Timebases

1, 5, 10, 30, 60, or 300 seconds

Flow Rates

Internal pump provides 50, 75, 100, 125 or 150 ml/min, DualSpot® compensation not compatible with all settings

Measurement Range

Per sampling location, 0-1 mg BC/m³, filter sampling location lifetime dependent on concentration and flow rate setting, decreasing proportionally with lowest wavelength optical source enabled:
IR only mode, average 5 µg BC/m³ for 24 hours at 100 ml/min
IR only mode, average 100 µg BC/m³ for 3 hours at 50 ml/min
IR only mode, average 1 mg BC/m³ for 15 minutes at 50 ml/min

Measurement Resolution

0.001 µg BC/m³

Limit of Detection

30 ng BC/m³, 5 min timebase., 150 ml/min flow rate, SingleSpot™

Pump Options

Standard internal diaphragm pump

Flow Control

Internal mass flowmeters with closed-loop control

Filter Material / Capacity

MA300/350 Filter Tape Cartridge with Polytetrafluoroethylene (PTFE) material (85 sampling locations)

Sampling

3 mm diameter spot(s) created on filter tape. User selectable DualSpot® or SingleSpot™ mode.

Environmental Sensors

Accelerometer, Relative Humidity, Temperature, Altimeter/Barometer

Dimensions

L: 199.90 mm (7.87 in), W: 99.82 mm (3.93 in), D: 69.85 mm (2.75 in)

Weight

965 grams (34.04 ounces)

Memory

16GB internal flash memory, providing storage for 31,250,000 data lines; 1 second timebase: 361 days of data

On-board Interface

Low Power Screen, 3 Buttons

Location services

GPS with Internal Antenna

Date/Time Format

ISO 8601 with satellite synchronization or manual computer synchronization

Wireless

802.11 b/g/n Wi-Fi with AES hardware encryption, Bluetooth Low Energy. Available in future firmware releases.

Connections

Via external sealed connector for 3.3V TTL Serial and DC power input via barrel jack, Aerosol sample inlet and outlet ports, USB 2.0 on inside panel

USB Communication / Client Application

USB connectivity to cross-platform microAeth® Manager software available on macOS® and Windows®. microAeth Manager software is included and facilitates settings configuration and data download. Exported data can be uploaded to AethLabs Dashboard server for processing and visualization.

Serial Communication

3.3V TTL serial connectivity for uploading new instrument firmware, flow calibration, streaming data and polling protocols to request data, modify settings and control. Command line interface (CLI) polling protocols: AethLabs protocol and Bayern-Hessen protocol.

Total Run Time

Up to 56 hours at 60 second timebase, 100 ml/min flow rate on single battery charge. Run time may vary due to PM concentrations and settings.

Battery

Internal 3.6V, 12800 mAh (46.08 Wh), 4 cell rechargeable lithium-ion battery

Charging

Fast charging DC via barrel jack AC adapter (~11.75 hours to full charge, instrument turned off) or USB charging (~25.75 hours to full charge, instrument turned off)
Power Supply Adapter: Input: 100~240 VAC 50/60Hz 0.4A, Output: 5VDC / 2A, with option for Type A, C, G, or I plug

Operating Environment

5 ~ 40 °C operating, non-condensing.

Specifications are subject to change without notice.

Specifications are subject to change without notice. microAeth MA Series products are protected by patent #8,411,272. Additional patents pending.

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