



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative



FEED THE FUTURE HAITI AREA PROJECT WEATHER STATION MAINTENANCE AND REPAIR MANUAL

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Weather Station Repair and Maintenance Manual (January 2020).

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Reason for the manual

William Eisenstadt of the University of Florida Department of Electrical and Computer Engineering presented a short course in July 2019 for a dozen Haitians who were trained as weather station technicians. The course attendees were able to construct, and repair custom solar Wi-Fi weather stations developed at the University of Florida. One of the outcomes of the short course was the need for having a repair manual which incorporated many of the short course materials. This manual would present information in a format that assists a technician in debugging and repairing a broken weather station. This manuscript is that manual.

About the Author

William R. Eisenstadt is a professor at the University of Florida Department of Electrical and Computer Engineering. Since 2015, he has designed, built and installed Wi-Fi weather stations for the Feed the Future Haiti AREA project in Haiti and in Gainesville, Florida. In this project, low-cost solar-powered Wi-Fi weather stations were developed to generate data to help farmers and for climate modeling. In addition, he provided training workshops for Haitians agricultural engineers who install, program and maintain weather stations.

In his latest work, Eisenstadt is developing new prototypes of wireless mesh weather stations for the U.S. Department of Agriculture (USDA) and mosquito districts for pest control and agriculture. Mesh networks interconnect many sensor nodes that communicate with each other and relay information. In addition, he is using internet-of-things (IoT) technology to measure soil health with nitrogen and other sensors. Eisenstadt is researching power integrated circuits (ICs) for automotive applications and custom sensor controller ICs for training in ophthalmological surgery.



He was program co-chair for the Wireless Test Workshop (2003 to 2010), has been a member of the International Symposium on Circuits and Systems (ISCAS) Conference, Analog Signal Processing Technical Committee, ASTPC, 2003-2019 and program co-chair of the 2016 Institute of Electrical and Electronics Engineers (IEEE) International Mixed-Signal Testing Workshop. Eisenstadt combines electronic design, packaging and embedded software design for wireless sensor systems in collaboration with leading researchers in entomology, power systems and biomedicine. Eisenstadt has over 35 years of experience in analog, digital and microwave test and circuit design. He has published over 180 refereed conference and journal publications, is the inventor of 16 patents and has advised 24 Ph.D. graduates.

Acknowledgments

The Feed the Future AREA project launched a weather station project in Haiti to develop a low-cost, modular weather station that uses open software and is relatively easy to repair. The idea was to create a weather station that was adapted to the special needs of Haitian agriculture. I would like to acknowledge the many contributors in the development of the University of Florida solar-powered Wi-Fi weather station for Haiti. These include the University of Florida (UF) graduate students who developed the Arduino weather stations that the AREA project designed and installed at several sites in Haiti in 2016. Subsequently, UF electrical and computer engineering undergraduates participating in the National Science Foundation's Multi-Functional Integrated System Technology (MIST) center developed a second-generation station with superior Wi-Fi features and data storage. Robert Corso, a University of Florida student, created much of the software that was adopted for the second-generation Haitian weather station. The AREA project provided funding for workshops for Haitians to learn about weather stations, including how to install, program and maintain them. I adapted these course materials and used his additional experience in maintaining weather stations to generate this manual. Key USAID supporters and collaborators in this effort included AREA staff Drs. Rose Koenig, Caroline Staub, Wesly Jeune, Absalon Pierre, and Lemâne Delva, as well as Will Blanc, an Haitian electronics expert. Charles Boisseau edited and formatted the manual. Much of the experience of repairing and debugging weather stations came from maintaining these stations at a U.S. Department of Agriculture site with the support of USDA entomologist Dr. Jerry Hogsette and at my home. These experiences proved essential in developing this manual.

— *William R. Eisenstadt*

Chapter 1: AREA Project Second-Generation Weather Stations

Background

Successful commercial agriculture requires an understanding of many factors, including soil, sun, crops, pests, pest control options, irrigation and micro-climates. The farm micro-climate in Haiti has extreme variations due its 2,715-meter variation in elevation and complex geography with coastline, rivers and mountains. Many places in Haiti have two wet seasons and the timing and the duration of the rainfall depends on the physical location. Temperatures in Haiti are tropical and vary significantly with elevation and proximity to the ocean. It is desirable to have weather reports across many locations in Haiti to provide farmers with critical data they need to make informed decisions about crop selection and the best time to plant and harvest. The weather of Haiti and the need for weather stations are reported in [1], [2].

In 2016, after I joined the Feed the Future Haiti AREA project, I began to work with volunteer graduate students at the University of Florida to develop weather stations for Haiti. We used the Arduino Uno processor [3], Electric Imp Wi-Fi board [4], and Arduino weather shield [5] from the SparkFun Electronics to connect cellphones and computers to the Weather Underground [6] website and cloud database. Our team completed the weather station package with a collapsible pole, solar power system and waterproof housing for the electronics. A team from the AREA project installed the first of what would be six AREA weather station at the Bas Boën Rural Center for Sustainable Development (CRDD). The weather station displayed real-time weather information and logged the results online via the Weather Underground.

In 2017, I traveled to Haiti to lead workshops on how to install and maintain weather stations. These workshops were attended by Haitian university faculty and staff, agricultural researchers, agricultural associations and meteorologists. In 2018, I developed second-generation weather station and IoT design and maintenance training for Haitian university faculty and staff, agricultural researchers, agricultural groups and meteorologists. This new instruction materials were delivered through workshops in Haiti. This work provided direct training to many Haitian professionals and courseware lab tools for Haitian universities to upgrade their curriculum. I presented a weather station technician's workshop in 2019 to a dozen Haitian agricultural engineers and scientists which included laboratories in which attendees built and programmed a second-generation weather station. At the end of this workshop, the attendees requested a repair manual to assist them in fixing the weather stations in the field. This manuscript is that manual. The specifications and fundamental features of the second-generation weather station are described in this overview section of the manual.

The workshop presentation materials, the weather station web links that report data on weather underground and documentation describing the USAID the Smart Climate program can be found on the USAID AREA program website [7].



Figure 1. First weather station installed by the AREA project at Bas Boën CRDD in Haiti.

The five weather stations installed in 2017 by AREA in partnership with Haiti organizations were designed to meet the needs of the Haitian agricultural researchers and farmers at a relatively low cost — roughly \$400 for materials. They were designed using modular parts to make them relatively easy to repair using widely available replacement electronics and instruments. However, to keep costs low, the weather instruments were not certified by the National Oceanic and Atmospheric Administration (NOAA). The stations collected data and broadcast the data via Wi-Fi to a local Wi-Fi router and then to the Weather Underground. Haitians can see the data as it is taken across the various weather stations and look up the old data in the weather underground historical records. The stations used open software so they could be programmed to collect and broadcast data to many cloud databases such as Amazon Web Services, Dropbox and Microsoft Azure. In addition, the weather station software could be modified to add new instruments or capability as needed. These stations were not locked into a commercial vender software and had no proprietary website or software restrictions.

After AREA installed five of these weather stations in Haiti, we soon found they needed to be upgraded to make them more reliable. In the field, the stations suffered from poor Wi-Fi connections, power outages and inconsistent reporting of data to Weather Underground's website.

New design

Starting in late 2017, I led weekly meetings with UF MIST center students to create a prototype of a second-generation wireless weather station. We developed a new processor board with the Photon Particle module with onboard Wi-Fi [9] and superior capability by adding microSD card storage and additional sensors on the weather stations. Students developed the computer code and debugged the new systems. We added many features to the code and to the hardware to increase the reliability of the second-generation station. We added a new external antenna connection, which enabled much further Wi-Fi transmission than the first-generation Arduino station. The station used a solar panel and a charging board that supplied power to the station and charged a 6000 mA (milliamperes)-hour battery for powering the station.

Additional improvements included upgraded software that cycles the station Wi-Fi on 10 seconds and off three minutes to save power and extend battery life, a watchdog timer that reboots the station if it stops working and a small lithium battery that saves data if the station power runs down.

Using the new design and parts, AREA staff upgraded existing AREA-installed weather stations at the National Association of Agricultural Producers for the Advancement of Agriculture in Haiti (ANAPAAAH) in Croix des Bouquets, on the campus of FAMV, at the CRDDs at Bas-Boën, Montrouis and Wynne Farm in Kenscoff. As with



Figure 2. An open second-generation weather station module showing the weather board on the right, the power board on the left and the battery on the bottom. The watchdog time is missing from the view.

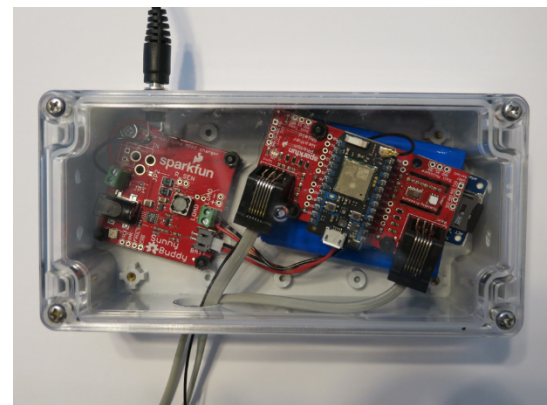


Figure 3. Finished weather station in a box with lid attached.

any such weather stations, these stations require periodic maintenance and repair. My hope is that technicians will find this manual useful when troubleshooting, repairing and maintaining these and similar weather stations.

Figure 3 shows the completed box and some of the modules inside. Since holes are made in the box, it is not waterproof, but it does protect the electronics from water when surrounded by the ambient weather shield [10]. This white weather shield is shown on the weather pole in Figure 1. Inside the box in Figure 2 are the Photon weather board with weather sensors and the Photon computer/Wi-Fi module. The cable connects the Photon weather board to external antenna and two cables connect the weather board to the weather instruments. A microSD board and microSD card are attached to bottom side of the weather board. A Sunny Buddy board inside the box converts the solar panel to 3.9 volts, supplies power to the weather station and to and from the battery. A blue lithium-ion battery is also inside. These are described below.

Weather instruments, weather board and SD card

The new stations include wind and rain gauges for measuring wind speed, wind direction, instantaneous rainfall and accumulated rainfall. These gauges are provided by Argent Data [11] and are in the bill of materials at the end report. There are additional sensors used by the weather station on the Photon weatherboard (purchased from SparkFun [12]) that measure temperature [13], humidity [13], pressure [14] and solar radiation. The Photon weather board connects to the weather instruments through Argent Data Systems' weather instrument cables with connector jacks. In this diagram, the temperature humidity and pressure sensors are on the bottom left of the Photon weather board. The socket for the Photon module is in the middle of the weatherboard. The Photon needs to be inserted and programmed before the weatherboard is operational. The weather board has been modified to include an Adafruit SD card breakout board [15] and a coin cell battery holder and battery underneath the board. At the time of report, the cost of the weather board was \$32.95 USD at SparkFun Electronics.

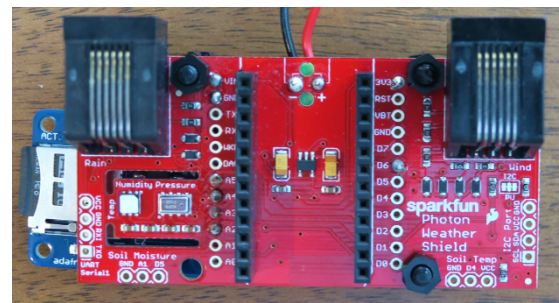


Figure 4. Photon weather board top side view. The black connectors are for the Argent weather instrument cables.

Two gray wires to connect to the wind rain gauges come through a hole in the side of the weather box as shown in Figure 4. These gray wires have registered jack (RJ11) connectors, which connect to the weatherboard black terminals. The wind gauge wire is wider than the rain gauge wire. In this photo, the wind gauge wire connects to the black terminal on the upper right of the Photon weather board (labeled wind). The rain gauge wire connects to the black terminal on the upper left of the Photon weather board (labeled rain). The weather gauges are shown with their wires in Figure 4.

The Photon weather station board is modified on the bottom to make power connections and to connect to the microSD board module. A terminal block (green) is soldered on the bottom of the board to connect power. A red line is connected to the plus power terminal and a black line is connected to the ground power terminal. A blue microSD board is soldered, and power and signals are wired to the Photon weatherboard. A power jumper is cut and re-soldered on the bottom of the board, too. The reader should look at Chapter 4 for more details.

SD Board Module

The microSD board and microSD card [15] were added to the weather station design to fix a design flaw in the Arduino-based first-generation weather stations. The dark blue board in Figure 5 is the microSD card. The smaller black rectangle in the silver sleeve on the left side of Figure 5 is the microSD card. The upgraded stations have an SD card that stores the data that is broadcast to Weather Underground inside the station. This is to prevent a log of data when the Wi-Fi is down (which happens frequently in the field in Haiti. Thus, a data log independent of the Wi-Fi is maintained. The SD board is soldered underneath the weather shield. An eight-gigabyte microSD card was placed in the SD board.

When operating in typical fashion, the microSD card receives the weather data every five minutes, independent of the weather data transmission via Wi-Fi to Weather Underground. The weather data takes up about 200 kilobytes a day or roughly 75 megabytes per year when recording data every five minutes. An eight-gigabyte microSD card has the capability of recording weather data for many decades. In 2019, the Adafruit microSD board cost \$7.50 and the 8 GB microSD card cost \$6. Most commercial weather stations don't have this data logger feature inside their electronics. Additional sensors can be added to the Haiti weather station and the data can be stored on the microSD card, too.

The data on the microSD card can be read as a spreadsheet on a Windows or Mac computer. It is recommended that a technician or staff member read the data of the microSD card periodically. The data is can be uploaded to a computer using a microSD to SD converter and a SD card slot on a computer or a microSD to USB converter. The file is stored in a .csv file format and can be read by an Excel spreadsheet or a text file editor. If there is interest and time, a programmer can develop weather station software to broadcast the microSD card data to a database on the cloud or to a cellphone.

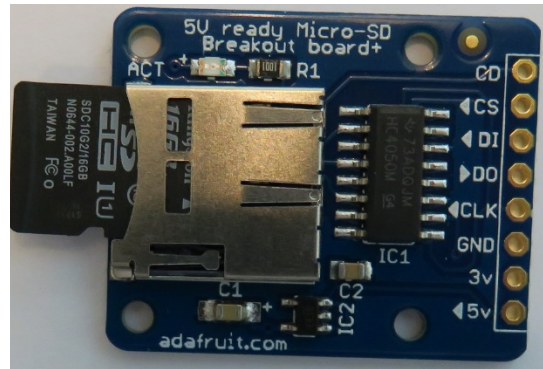


Figure 5. The microSD board used in the weather station.

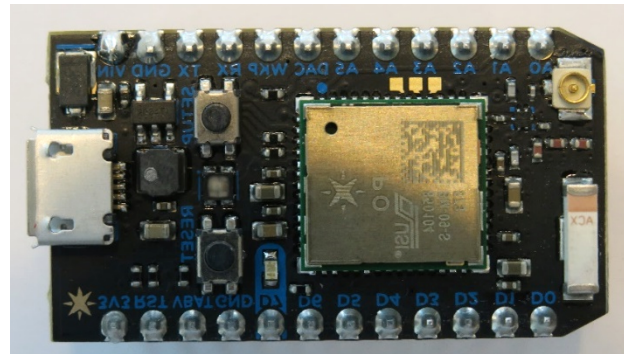


Figure 6. The top view of the Photon module.

Photon Processor Module

The microcontroller in the weather station in the weather board is the Photon Particle processor module [9]. The Particle Photon board has a 120Mhz Clock AMD Cortex M3 processor with 1MB of flash memory of which 128K is accessible for programming. In addition, there is 128K of dynamic RAM for program variables. There is a built-in Broadcom Wi-Fi chip with an internal module antenna (external antenna connector too), for cloud connections. The module has a real-time operation systems, and software is compiled and downloaded from the Particle Industries Inc. Build Integrated Development Environment, or IDE, or Microsoft Visual Studio with Particle programming extensions. Particle provides extensive libraries for programming peripheral devices and connecting to the cloud. The module is powered through a USB Micro B connector and was available online for \$19. A good starting operational and programming guide for the Photon Module is found in the references [16].

Solar Power System

The solar system is powered by a six-watt, nominally six-volt solar cell purchased through SparkFun (see the weather station bill of materials section). There are 9W, nominally 6V solar cells available from SparkFun, too. Other cells can

be used but the maximum voltage output of the cell should be less than 20V. Note the 6V cell has maximum voltage of 9V when there is no load. (It is open circuit.) A 12V solar cell can have an open circuit (no load) voltage of 22V. This is beyond what the solar power converter recommends so don't use these higher-voltage cells with the SparkFun Sunny Buddy board.

This 6W 6V cell provides sufficient energy to drive the weather station and to charge the lithium ion battery through the SparkFun Sunny Buddy board [17] [18]. A lower wattage cell will be slower and less effective. The solar power output is connected through a 5mm wide jack (black cable) through the weather box to the Sunny Buddy board.

The Sunny Buddy power supply board converts the solar cell output to 3.9V for the electrical modules and the lithium battery. The power supply system automatically switches to battery mode from solar power charging when there is insufficient solar voltage provided by the solar cell. The cost of the Sunny Buddy board was \$25 in 2019. A second 6V solar panel can be added to the system if needed by modifying the Sunny Buddy using the instructions in the SparkFun website at <https://learn.sparkfun.com/tutorials/sunny-buddy-solar-charger-v13-hookup-guide-/all>.

A 6000 mA-hour lithium ion battery charges to 3.9V maximum and is rated at 3.7V. Smaller lithium ion batteries can be used but they will hold less charge and operate for shorter periods if there is no sun. The 6000 mA-hour battery will last roughly six to seven days if it is fully charged and there is no solar power coming into the system.

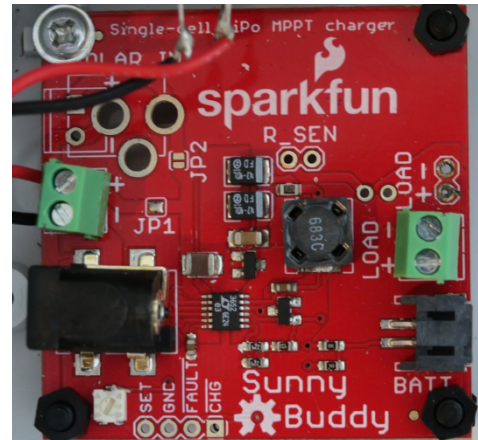


Figure 7. Sunny Buddy board from SparkFun.

Antenna Communications

The Wi-Fi communications for the weather station are routed through an external antenna. The Photon module has a U.fl connector which can be connected using a proper cable to an external antenna with a subminiature version A (SMA) connector. An antenna that works with the Photon is specified in Chapter 10. This external antenna mounted on the ambient weather shield [10] is connected by cable through the plastic box to the Photon radio frequency (RF) transceiver. The external antenna provides about 100 times more RF signal power to the system than using the internal antenna provide with the Photon module. It is necessary to program the Photon module to always use the external antenna. These antennas increase the transmission distance to 20 meters and in a single antenna and cable cost \$3. The antennas are sold in packages of two as shown in Chapter 10.



Figure 8. External antenna and cable that provide enhanced Wi-Fi communications.

Rain and Wind Gauges and the Weather pole

The light gray rain and wind gauges are shown in Figure 9. The rain and wind gauges are mounted on a custom weather pole that lifts them well above the ground and exposes them to unobstructed rain and wind. The wind gauge has three cups that spin and the weather system counts the number of rotations of the cups to determine the wind speed. The gray box contains a rain gauge. Rain enters the top of the box. The rain gauge is a self-contained catch-and-release system in which a fixed quantity of rain is collected in a cup and then spilled when it reaches a critical amount. The weather station counts the number of times that the rain gauge is filled and spills rain.

A wood or metal pole can be used for mounting the weather station. Figure 1 shows the weather station mounted on a wooden pole.

The placement of weather pole is critical to measuring useful weather data. Rain and wind sensors should be located over open, level terrain, ideally a distance equal to 10 times the height of the closest obstruction. So, if there is a 3-meter-tall tree, the weather station should be 30 meters from it. Temperature and relative humidity sensors should be located over an open level area at least 10m in diameter or at least 30m from a large paved area.

The pole must be high enough to catch the wind unblocked by trees or structures and to keep the electronics dry. Take care to have the weather station away from any irrigation sprinkler than sprays water at a tall height into the electronics.

The rain gauges are attached to the top of the pole. The outer diameter of the metal weather gauge pole is 2 cm or 25/32 of an inch. There needs to be a flat platform attached to the pole to mount the solar panel. The solar panel should be exposed to the sun without shade throughout the day. In the northern hemisphere, it is good to put the solar panel on the south side of the weather pole, so it is exposed to the angled sun in the winter. The pole needs to be secured at the bottom which can be done with concrete or a deep hole. The Photon module broadcasts using Wi-Fi so the weather station should be near a Wi-Fi transceiver.

Software system

The organization, installation, modification and cloud communications for the software for the weather station is described in the Chapter 8 of the report. The weather station is programmed through the Particle IDE online, where you will find programming support, tutorials and a programming community forum [19]. In order to use this software to program the weather station, it is necessary to set up an account on the Particle Industries' website. The programming of the Particle Photon is discussed Chapter 8.



Figure 9. Wind and rain gauge in the weather station.

Chapter 2: Why Isn't the Station Working?

The most important step in maintaining the weather station is determining what is the overall cause of its failure. Fortunately, there are many clues to these possible causes if the station is found to be not working. By going through these clues and indicators, a lot of time can be saved. This section defines the general causes of weather station failures. Once the cause(s) is determined, you can refer to the pertinent chapter to fix the station.

What follows are some issues and questions weather station operators can ask to troubleshoot problems.

Troubleshooting: Local Wi-Fi broadcast Issues

Is the Wi-Fi working?

Without the Wi-Fi there is no data reported to weather underground and the station cannot be reprogrammed or initialized to the particle cloud. There are some cell phone apps to look at the Wi-Fi in a local area. The author likes “Wi-Fi Analyzer,” which on a Windows PC platform shows all the local networks, their names, bands and broadcast power. There is limited Wi-Fi information on the free Apple iPhone Apps. you have to purchase a phone App upgrade to obtain this information.

To successfully receive and broadcast the weather station should have at least -80dB strength Wi-Fi signal where it is located.

If there is insufficient Wi-Fi signal or no Wi-Fi, a technician must install Wi-Fi or add a Wi-Fi extender to bring the Wi-Fi to the weather station. There are many commercial Wi-Fi range extenders and Wi-Fi boost modules. Another solution is to put an ethernet cable (connected to an ethernet router) and a long waterproof power cable to a Wi-Fi in a sheltered waterproof place near the weather station.

The weather stations have long external antennas and can pick up relatively weak Wi-Fi signals. *Chapter 5 presents the details of the Wi-Fi signal evaluation in the second-generation Haiti weather stations and methods of repair.*

What if the Wi-Fi is working and there is enough signal strength but there is no connection?

Determine if the Wi-Fi password or SSID was changed recently. If it was, then the weather station will have to be reprogrammed for the new password and SSID. See chapters 5 and 8. If there is Wi-Fi has sufficient signal strength and the password and SSID are not changed then it is time to go to the next section on broken weather station analysis.

Troubleshooting: Other causes of failure

The primary failure of a weather station is the loss of power, which can be caused by several factors.

1. **The first thing to look for is whether all the weather station wires are connected properly.** Are all the rain and wind gauges functioning and connected? If wires are disconnected the instruments may not record data, the solar power may be disconnected from the station module or the antenna may be disconnected. Replace broken rain and wind sensors and sensors with missing wires with new sensor modules. See the paragraph about the Argent weather instruments in the introduction to view these connections. Add a new solar power cable if it is missing or broken. It may be necessary to use a multimeter to check the wiring voltages in the electronics box as described in Chapter 3. Complete documentation on the weather station

wiring is found by accessing the Weather Station Technicians' Workshop Slides we have posted online; the URL at this writing is <http://bit.ly/weather-station-3>.

2. **The next thing to determine is whether the weather station electronics were abused** while operating in the white Ambient weather shield. Was a sprinkler shooting water into the weather station electronics? Are there lizards or bugs inside the weather station box? Was the weather station knocked down or did the white weather shield fall off the weather pole? Did lightning strike the weather pole or the station? If any of these things this happened it may be necessary to replace some or all electronics. A technician will have to go through and examine all the parts to see if they work using the instructions in this manual. Usually, if the station operators take care of the system you won't find broken cables or abuse. Then it will be necessary to determine whether there is power going to the instrument module.
3. **Check the LED lights.** Again, if there are no lights (LEDs) on in the station, there is a complete power failure. You can see the LEDs by looking between the plastic Ambient weather shield pieces. You can loosen the wingnuts on the screws holding the weather shield together to better see inside. You may have to shade the station while you look since the mid-summer sun can be very bright and mask the LEDs. There should be red LEDs for the watchdog timer and an LED that changes color on top of the Photon module. The Photon weather board has the Photon module with an LED lit in the center of the module. This Photon LED switches to many colors (white, green, blue and cyan) if it is working. Test the power cable with a multimeter to see if it conducts and add a new power cable if necessary.
4. **Make sure the weather station is placed in the sun** most of the day otherwise there may not be enough energy being placed in the battery. The solar panel should not have much if any shade and should be exposed to sun if it is a sunny day 90% of the time. Make sure that there will not be shade on the solar cell with the placement of the sun in the sky during winter as well as during summer.
5. **Is there a problem with the solar panel/battery or board?** If the power cable is good and the LED lights are off then there is a power problem with either the solar power panel, the battery and/or the Sunny Buddy board. *If so, go to Chapter 3 on Fixing the Power and the Solar System.*

If the power seems OK, look for reasons the program is not working in the electronics.

1. **Remove the ambient weather shield with the weather box and the rain instruments from the weather station.** A technician will need to unscrew three screws connecting the weather shield to the plastic arm that is attached to the weather pole. The power cable must be disconnected from the solar power panel. Be careful not to lose the three screws in the dirt, because they are dark and almost impossible to find if they drop on the ground. Take the weather station assembly to a table or good workplace where it is safe take things apart and where you will not lose small parts. Take the weather station box full of electronics out of the ambient weather shield. Open the electronics box. The Photon module (LED) light should be cycling from white to green and even blue or cyan every five minutes. If other colors being shown, then the processor is not functioning properly. For instance, red means that the Photon module is not able to connect to the Wi-Fi. Cycling through colors very quickly can indicate the weather station is constantly resetting. This would be caused by a misprogrammed watchdog timer constantly resetting the system. The Photon module LED states are presented in the Weather Station Technicians Workshop Slides and in the online documentation of the Particle Photon IDE for programming. A technician will need to figure out what is going on with the Photon LED lights if possible. *See the Weather Stations Technicians' Workshop Slides for the meaning of the lights on the Photon module.*
2. **There may be a failure of the weather station during electronics installation.** This has to do with the microSD card and card reader. Quite simply, if the microSD card is missing or is not properly inserted into the microSD card reader the weather station can fail to operate properly or shut itself down. The weather station code expecting to be able to write to the microSD card and creates errors when it is not there. It is unpredictable what will happen to the weather station software when the microSD card is

not there, it can just stop. When the weather station electronics box is open and the microSD card is visible, you can see a little red LED that flashes when the card reader is operating. The red LED should come on for a long period of up to 30 seconds when the weather station starts then turns off. After that, the microSD card should flash on for less than a second to up to 3 seconds every time the weather station does a write to the SD card. If these lights are not flashing, then data is probably not being written to the SD card and the weather station may fail. Also, if the lights are not flashing there may be a bad microSD board or bad connections to the microSD board from the Photon weather board. A technician needs to check the microSD card data on the PC to find out. Generally, if there is a bad microSD board, it is very difficult to unsolder and replace. So, a new weather station board must be prepared with a new microSD board.

3. **Watchdog timer.** Another station failure that is simple to fix is a misconnected or poorly programmed watchdog timer. Please refer to the Weather Station Technicians' Workshop Slides on how the watchdog timer should be connected to the rest of the weather station electronics and how it is programmed for a 200-second delay. If a power connection to the timer is missing, then the watchdog timer is not working (red LEDs are not lit). Then, the watchdog timer will not reset the weather station if there is a power failure or a communications lockup. If the watchdog timer is not slowed down to its maximum delay of 200 seconds, it can interrupt and reset the weather station faster than the station operating properly can stop it. For instance the watchdog timer could be set up incorrectly to reset the weather station every 10 seconds and the weather station would never get out of its startup section of the program. It would just constantly restart. If the wire connections to stop resetting the watchdog timer are not made or if the program variable for stopping reset from the watchdog timer is not initialized correctly then the watchdog time could reset the weather station every 200 seconds. In that case, the station would probably record data on the SD card but not broadcast data to weather underground. *Refer to Chapter 8 about programming to help fix this.* The watchdog timer variable is in line 213 in the program at the time of this publication. *Line 213 `volatile int watchdogSignal = 1; // Strobes the watchdog timer when true, can have watchdogSignal = 0 if there is no timer, (but must have watchdogSignal = 1 if there is a watchdog circuit).`*
4. **Another cause of failure can be leaving the weather station in testMode =1.** Having testMode= 1 is very useful in allowing the weather station to put serial output to the computer and watching the program and instruments for debugging. However, the weather station code requires testMode = 0 to enable data transmission to Weather Underground. *Refer to Chapter 8 to fix this.* The important program line at the time of writing this document was line 212: *Line 212 `volatile int testMode=0; // sets up serial printout and turns off WU delivery for test mode when true, testMode =1, (must have testMode = 0 to broadcast data).`*
5. **Another big source of information about how the weather station is operating is in the microSD card** that is connected to the Photon weather board. If the weather station has operated properly for a period, there should be a record of the weather data on the microSD card as well as the received signal strength indicator (RSSI) Wi-Fi signal strength. A technician can take this microSD card and connect it USB microSD card converter into a computer and read the data with the Excel program or a text editor. The data on the card will show if the instruments are taking reasonable values of temperature, wind speed, rain, air pressure and humidity. If the temperature, humidity or air pressure values are bad, it will be necessary to replace the Photon weather board. *The preparation of a new the Photon weather board is presented in the Weather Station Technicians' Workshop Slides.*
6. **If the wind and rain values are not reasonable on the USB drive data, then there is something wrong with the sensors or sensor connections.** Typically, if there no broken plastic in the rain and wind sensors, there are reversed connections to the weather board in electronics box. That means that the instrument cables to the RJ11 jacks are switched and connected to the wrong sockets. This is easy to repair by reversing the cable connects in the sockets. If the USB drive shows good data every five minutes for many weeks and then there are suddenly big gaps in the data, this indicates an intermittent

power problem. The station may be ok with the long summer days but having a shading problem in the winter. Then the station runs out of energy and does not record data when it gets late at night. The station then starts up again in the mornings with sunny days. This indicates that a larger solar cell maybe required or the station weather reporting to weather underground should be slowed down to longer than once every five minutes. If the USB drive shows no recorded data, there is a problem with the drive and the USB card. Please go to the section on Fixing the microSD card and reading the microSD card data.

7. **Reload program and swap bad/old boards and modules.** If the power is going into the weather board and the processor and the watchdog timer but the station does not work, try reloading the weather program and swapping new boards and modules for broken and/or old ones. One cause of a Photon module not working is that Photon Industries updates the module operating system over the Wi-Fi. The amount of time the weather station is connected to the cloud when operating is insufficient for the module to be properly upgraded with cloud software. So, the first step in working on the electronics box is to test these points in the power circuit, take a 5V wall charger for a Photon module or an Arduino (they are the same) and power it up through the wall plug and connect the 5V output to the power board through the electronic box 5mm power terminal. If this wall charger lights up the Photon module and the weather station starts working, then there could be a battery problem or a solar cell problem. A technician will have to work through this repair with the instructions in Chapter 3 on the Fixing the Solar Power System section. The most common cause of failure of these electronics is a broken wire or a wire that is soldered poorly. Make sure that all the wires that go between electronics are connected properly and none of them are broken. Also, check the connections with a multimeter to see if voltages to the electronics are there. A bad solder joint will give low voltages and this happens fairly often. If the module does not work but there is 3.3V or more coming into the Photon power board, check VCC or Vin label points, and use a multimeter to measure this, then it is time to reprogram or replace the Photon module. *You can see how to do this in Chapter 8.*

If there is an upgrade to the Photon processor software operating system, then the programming will take some extra time. The processor will wait while it receives new system software from Particle Industries.

You can tell if the reprogrammed processor is working by looking at serial monitor in test mode. Take off the watchdog timer to do this. If the Photon processor still does not work, you will have to program a new one. Once you have a processor program is working in test mode on the serial monitor then you can test the rain, wind and temperature instruments on the SparkFun Photon weather board. If the instruments do not give you changing data on the serial monitor in test mode, you need to replace the SparkFun Photon weather board.

Once the Photon module program and SparkFun Photon weather board instruments work, reconnect the watchdog timer. You probably want to install a final weather station program with testMode=0 to broadcast to Weather Underground, save energy and simplify the program operation when you are ready to put the electronics back into the weather station electronics box.

Put all the working electronics in the box as you found and the reassemble the Ambient weather shield with the box, and install the weather shield, the box and the wind and rain instruments. The Weather Station Technicians' Workshop Slides give detailed instructions on how to do this.

Chapter 3: Fixing the Station Power and Solar System

The weather station power system is critical for the weather station to function autonomously in the field and is often the point of failure of the weather station. This chapter reviews how the weather station power system works and how to test and fix the power system if a part fails. In general, it is straightforward to tell if there is a power problem. If all the LED in the watchdog timer circuit and the LEDs on the Photon module are off, then there is no power to the weather station circuits.

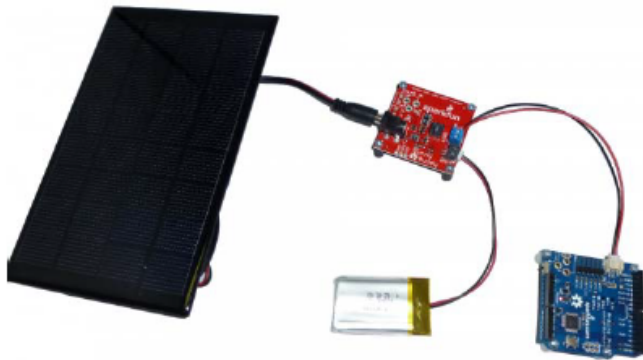


Figure 10. This is the system diagram of the power elements in the weather station.

Error! Reference source not found. shows an example power system used in a weather station. On the left side you see a solar cell. It is connected to a red Sunny Buddy board provided by SparkFun. The solar panel when illuminated with bright sunlight puts energy at roughly 9V into the Sunny Buddy board. The Sunny Buddy board takes that energy, converts it to a reduced voltage of 3.7V to 3.9V. This 3.7V to 3.9V is to both the weather station electronics boards and a battery.

Below the Sunny Buddy board in Figure 10 is a white lithium polymer (Li-Po) battery which powers the system when the solar has no energy. To the right of the Sunny Buddy and blue battery is a blue board which represents the weather station “load” that draws power. This board represents all the electronic boards and (modules) that are encountered inside the weather box. Currently, the Sunny Buddy board provides power to the SparkFun Photon weather board, the Photon processor board and a watchdog timer board. **Error! Reference source not found.** shows the Sunny Buddy board attached to the power cable from the solar system on the left. The Sunny Buddy powers the SparkFun weather board and the Photon module which is on top of the SparkFun weather board. The watchdog timer is out of the box but is placed above the Sunny Buddy board with spacers to keep them separate. The purchasing and technical details for these parts can be found in Chapter 10.

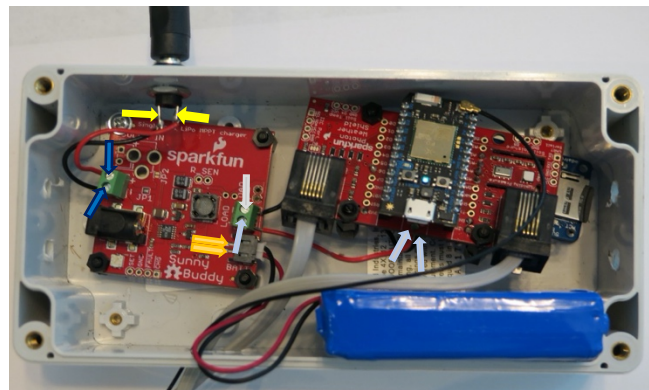


Figure 11. The Sunny Buddy and weather boards inside the weather station electronics module.

The most common cause of failure of the power system is a broken wire or a wire that is soldered poorly.

Make sure that all the wires that go between electronics are connected properly and none are broken. Also, check the connections with a multimeter to see if voltages to the electronics are there. A bad solder joint will give low voltages and will have to be resoldered. In particular, the wire connections from the 5mm black barrel connector cable to the box power terminal and the box power terminal to the Sunny Buddy board tend to break. These potential power connection breaks and bad solder points are shown with yellow arrows in **Error! Reference source not found..** These black and red wires can break if the weather station box is opened and the electronics are moved around. In addition, there can be cold solders (open solder connections) on the soldering of the wires to the 5mm box connector. Other consistent points of power failure are shown by the blue arrows. Here, the connectors can get loose from the power blocks or not be soldered in correctly. It is important to test all the points on the circuits to see if they are getting the correct power.

First, a technician should look at the battery terminals of the SparkFun weather board when there is no power applied to the weather box. The battery is the blue rectangular box in **Error! Reference source not found..** Make sure it is there and connected to the Sunny Buddy board when this test is done. These test points are shown with the mustard-colored arrows on the circuit board. The difference between the Li-Po battery terminal voltages should be $>2.9V$. If the Li-Po battery goes below $2.9V$ it can be damaged and will not operate properly and hold enough charge. If not replaced, the result will be a weather station that works when the sun is up but the battery discharges quickly and the station turns off after a few hours. The solar battery will last six days or more without charging on the weather station if it is fully charged and in good shape (the output does not go below $2.9V$). If the battery is not working because of low voltage, a cause could be a broken wire in the power circuit as discussed below. Additionally, the battery may need to be replaced after a year or two of normal wear.

The battery specifications are for a 6000mA-hour battery (roughly \$30), though other batter options are available, including 1000mA-hour (\$9.95) and 2000mA-hour (\$12.95).

To test the power connection wires and points in the power circuit, use a 5V wall charger for a Photon module or an Arduino (they are the same) and power it up using a wall plug and connect the 5V output to the power board through the electronic box 5mm power terminal. If the wall charger lights up the Photon module and the weather station starts to work, then there could be a battery problem or a solar cell problem. You will have to work through this repair with the instructions in this section.

Once you power up the device you can test the voltages and see if power is being distributed correctly. The voltages at the yellow arrows should be well over 5V. The Arduino wall chargers put out $9.2V$. So there should be $9.2V$ or so between the yellow terminals in **Error! Reference source not found..** This voltage should be conducted by the red and black wires to the blue arrows in **Error! Reference source not found..** So, the terminal block screws under the blue arrows should have the same voltage difference as the wires under the yellow arrows. For my charger that would be $9.2V$. If this voltage difference is not the same there is a wiring problem and a wire needs to be re-soldered or replaced.

Next, test the wires (the white or off-white arrows in Figure 11). These should be around 3.9 to $3.7V$ with the wall charger plugged in. If they are below $3.9V$ to $3.3V$ under the Sunny Buddy board arrows there could be a broken Sunny buddy board. Sometimes the voltage converter integrated circuit burns up on the Sunny Buddy board and the board no longer converts the high voltage input to a useful voltage 3.9 to $3.7V$. If this voltage is low $3.7V$ to $3.3V$ on the Sunny Buddy board there could be a discharged or broken battery which is discussed below. If a new Sunny

Buddy board replaces a broken one, the new board needs to be adjusted so the output charges efficiently using the instructions in the Weather Technicians' Workshop Slides. If this adjustment is not made the weather station will still work but not charge the battery as efficiently.

If the voltage is 3.9 to 3.7V with the wall charger powered up connected to the Sunny Buddy board under the white arrows then the same voltage should be seen in the terminal connector under the white arrows at the SparkFun weather station board. In addition, 3.9 to 3.7 volts should be seen between VCC and ground on the terminals of the SparkFun weather station board and at the power terminals connected to the Photon processor. If this is not seen then there is a break in the wire connections between the Sunny Buddy board and the SparkFun weather station board. You have to correct the wiring so that the voltages are correct.

The last thing that can fail in the power system is the solar panel. The solar panel installed with the weather station is a 6V, 6W panel. With full sun it can supply 1000mA at 6V and run the weather station and charge the Li-Po battery. The solar panel costs \$59, based on an online search in early 2020.

Very hot weather can degrade the plastic coating on the solar panel. In addition, dirt and leaves can block energy from being collected by the solar panel. The weather station technician should try to clean all the dirt and dust off the solar panel every time the weather is serviced. There have been a couple of times the solar panel has broken on these weather stations. In the first one the plastic coating looked aged after 3 years and the panel did not give out any energy. You can test the panel by placing it in the sun and putting the multimeter across its terminals. It should produce roughly nine or more volts if there is no weather station connected. The second test is to put the solar panel in the sun and connect it to the working weather station. The weather station lights should turn on. There should be at least five volts at the yellow arrows in **Error! Reference source not found.** when the solar panel is connected and pointed at the sun.

Chapter 4: Fixing the Station Weather Sensors

Hand-testing weather sensors

The second-generation Haiti weather stations have a set of weather sensors that should be inspected for wear and can be hand-tested for operation. Make sure all the sensors below don't have broken plastic or cables; if they do they will need to be replaced.

You can measure the weather station instruments using a multimeter set on resistance. The hookup can be seen in the schematics in the weather instrument documentation below. It is easier to measure the instruments when plugged into the weather station board. You can turn the weather wind meters and see the value for resistance go from near 0 Ohms to a high value. You can toggle the rain meter and see the resistance go from near 0 Ohms to a high value. If you turn the weathervane it should give different values of resistance. These values are given in by the Argent water instrument documentation. If nothing happens during the Multimeter testing then the weather instrument is broken.

However, the much easier way of seeing what is wrong with the weather instruments is to get the weather software running in test mode. This is reviewed in Chapter 8. Then, you can see what is being measured on the computer screen every second. You can turn the wind instruments or toggle the rain meter up and down and see that the weather instrument data changes on the screen. In addition, you can see if the temperature sensor is working (the IC with the white membrane on top and the marking "temp" on the weather board). Bring your finger close (but don't touch) to see if there is an increase in temperature.

If any of the instruments are bad on the weather board, the weather board needs to be replaced.

The schematics below can be used to look at these measurements and to ensure that signal and power is delivered to all the instruments. On the weather board is a temperature and humidity chip and an air pressure chip. Off the board the Argent instruments are connected through the phone RJ11 jacks to the Photon processor. By carefully going through the schematics and reading the DC values a technician can determine what is wrong.

Schematics for debugging the SparkFun Photon Weather Board

These schematics photos are from the SparkFun weather board documentation are available through at: https://cdn.sparkfun.com/assets/4/6/b/6/8/SparkFun_Photon_Weather_Shield_v11b.pdf

It is recommended that a technician download the schematics to understand the basic function of the weather station boards.

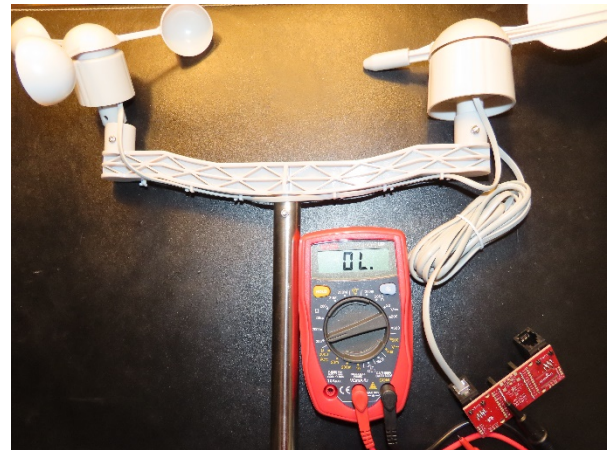


Figure 12. The wind meters and rain meters used for the weather station measurements.

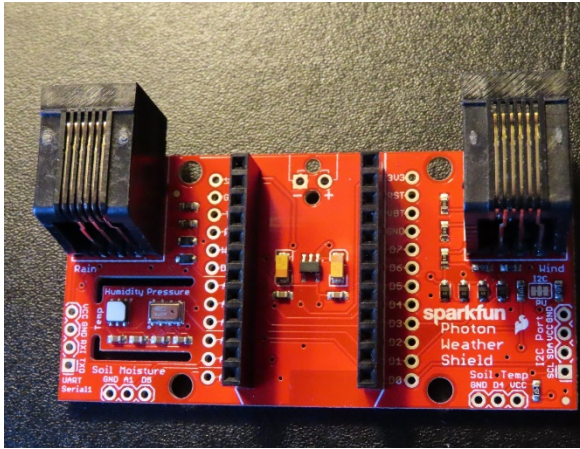


Figure 15. SparkFun weather station board (front side).

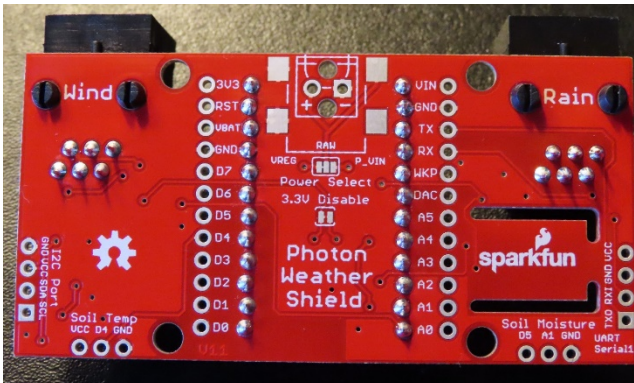


Figure 14. SparkFun weather station board (back side).

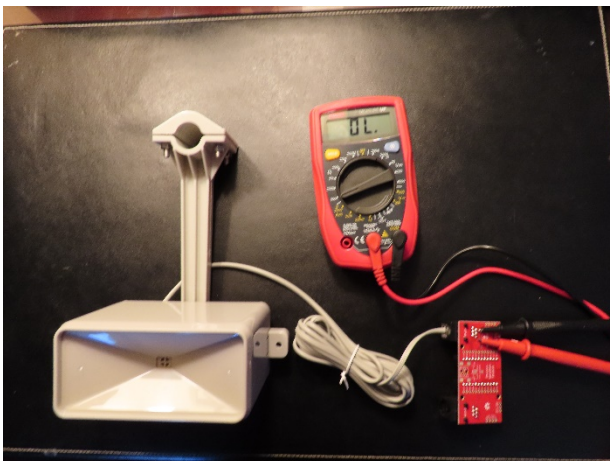


Figure 13. Rain instruments hookup for testing with a multimeter.

Chapter 5: Fixing the Station Wi-Fi communications

Before the weather station can communicate with Weather Underground or the cloud it needs to get the correct Wi-Fi SSID and password for the weather station program. This is done when a Photon module is programmed with the Photon App and made to communicate with the local Wi-Fi. But, if the Photon loses power, or the Wi-Fi goes down, the Photon will search around for other Wi-Fi links or use old Wi-Fi links in its memory. So, it is very important to have the weather station software use the local Wi-Fi and password and put this in the program so the Photon does not get lost when the station is reset. The lines below show the program code for setting the Wi-Fi, just insert the local SSID and password between the quotation marks.

Unfortunately, the Wi-Fi password has to be updated in the weather station program every time the password is changed. So, this is something that may have to be done every few months.

```
207 retained char ssid[] = "ATT-WIFI";           // weather station wifi SSID
208 retained char password[] = "MIST123456";      // Weather station wifi password
```

Figure 16. Weather station code that has the Wi-Fi SSID and password.

Let's review RF power levels and measurements that you can expect when repairing the second-generation Photon weather station. The RF power is measured and reported by the Photon module using an RSSI variable which stands for Received Signal Strength Indicator. This, the Photon Wi-Fi chip can tell you how much energy it is receiving from the Wi-Fi router. Power is measured in the Photon module in the units of dBm which is a decibel representation of milliwatts or watts/1000. A typical Wi-Fi system can broadcast up to 100mW, 20dBm at 2.4 GHz or 200mW (23dBm) at 5.0GHz. Every time you reduce the value of the dBm by 10 you are reducing the power by a factor of 10 times. So a 0 dBm signal is 1 mW and a -30 dBm signal is 0.001mW or 1 microWatt. An excellent level of power for communicating to the Photon Wi-Fi RSSI is higher than -40dBm. An acceptable and reliable level of power for communicating to the Photon Wi-Fi RSSI level is above -70dBm. And RSSI level of <-85 dBm is a poor power level and would result in poor or intermittent communications.

```
Sun Jun 23 12:09:30 2019 Year: 2019 millis: 84108
11: 1Solar Array Voltage, 11.22 wifiStrength: -51
on boolean OFF. CloudTest == 0
```

Figure 17. RSSI signal strength measurement using the serial monitor of the Photon program.

The Photon RSSI is measured through the serial port monitor or through the particle cloud. During set up or debugging is easiest to measure for the serial monitor and see the value on a computer. Please refer to the section on programming the weather station and it will show you how to set up and operate the weather station in test mode; this mode reports RSSI every second. However, RSSI is only measured when signal is broadcast to Weather Underground. So the value only changes every few minutes.

Wi-Fi measurement is command: *Wi-FiStrength=Wi-Fi.RSSI()*.

The Photon weather station uses an external antenna to best communicate the weather data. The Photon module has a built-in chip antenna that is relatively inefficient at collecting signal. In order to use an external antenna at all times special code is required. This code has a use external antenna command: *STARTUP(Wi-Fi.selectAntenna(ANT_EXTERNAL));* // chooses between antennas (ANT_INTERNAL, ANT_EXTERNAL, ANT_AUTO). The external antenna is an improvement of up to 30 decibels, or 1000 time more signal power than the internal antenna.

Figure 19 shows the Particle Photon module mounted on the SparkFun Particle Photon board and connected to an external antenna for receiving signal. The specifications and details of the antenna and cable necessary to connect to the Photon are in Chapter 10.

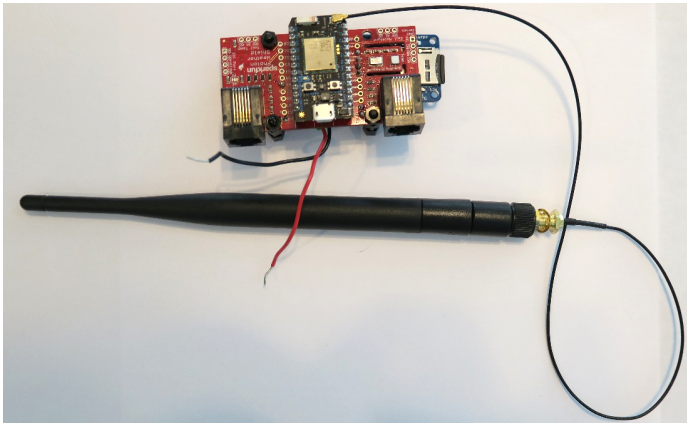


Figure 18. External antenna connected through a cable to the Particle Photon module.

One end of the cable that connects to the antenna is mounted on the plastic ambient weather shield so that the antenna can point up and outside the weather shield. A hole must be made in a leaf of the plastic shield for mounting the antenna. Use a drill to make a 1/4-inch hole. One end of the cable has a standard SMA connector while the other has a U.FL/IPEX connector that will allow it to connect to the Photon module. Use the Weather Station Bill of Materials in Chapter 10 to guide your antenna and cable purchases because there are a confusing assortment of RF connectors and it is easy to buy something that won't work.

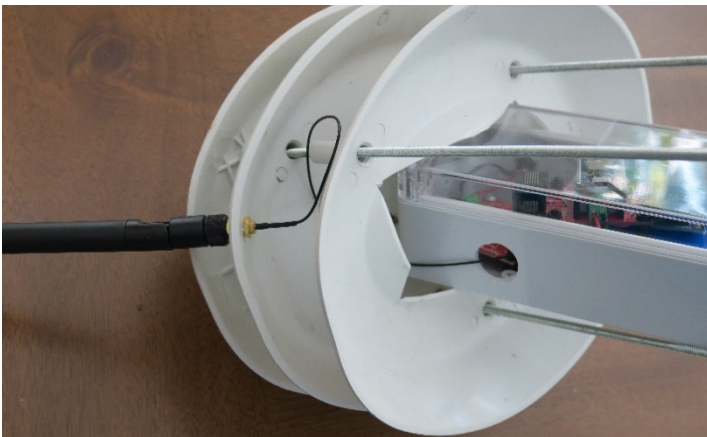


Figure 19. The antenna connection to the weather electronics box.

In **Error! Reference source not found.** you can see cable connection to the antenna through a hole in the plastic ambient weather shield. The cable then is threaded to the center of the weather shield and goes in a whole in the weather box and is connected to the particle Photon RF connector terminal. The antenna is fixed vertically on the ambient weather shield and pointed toward the Wi-Fi access point. Using this external antenna the signal is 100 to 1,000 times stronger than if the antenna is not present.

It is important to connect the cable firmly on one side to the antenna using the given mounting screws and twisting the antenna firmly. If the antenna is pointed away from the Wi-Fi access point or at the ground it will receive a significantly less of a strong signal. In addition, to make sure that there is a good connection between the small

connector at the end of the cable to the Photon module. This should be snapped into the module terminal and not be loose.

Unfortunately, regular failure in Photon weather stations is weak Wi-Fi reception caused by poorly made Photon modules. Having worked with dozens of new Photon modules, a few of them receive a very weak signals compared with the majority of them. It may be necessary to discard modules that seem to have exceptionally low RSSI levels. The test is to look at the RSSI level when the weather station module is pretty close to the Wi-Fi access point and not in the field. The RSSI levels should be greater than -45dB. Placing the Wi-Fi modules out in the field will reduce the weather station signal power levels up to -40 dB. Starting with a weak Photon module Wi-Fi receiver near the Wi-Fi access point and moving out to the field will result in levels of less than -85 dBm and unreliable or poor communications.

In addition, there have been situations where excessive connection and reconnection of an RF cable to the Photon modules and the antennas make the RF connectors and cables work poorly. In particular, excessive stress or pulling on the cables can cause degradation of the connector performance. This can happen if the weather station is dropped, especially when it is being installed or uninstalled on the weather pole. If this is the case, it is prudent to install a new cable antenna and clean up this problem.

In summary, it is always a good practice to check the RSSI signal levels of the Photons to make sure they acceptable either when first putting them in the field or when debugging or fixing a broken weather station. This is done using the serial monitor and the weather station in test mode when it is being reprogrammed near the Wi-Fi access point.

It is also useful to check the Wi-Fi signal levels at the weather station pole with Wi-Fi monitor apps using a cell phone or a computer. You can download an app such as Net Analyzer to view the Wi-Fi in a local area.

If the power at the weather pole is insufficient or there is no Wi-Fi, you must install Wi-Fi or add a Wi-Fi extender to bring the Wi-Fi to the weather station. Another solution is to put an ethernet cable connected to an ethernet router and a long waterproof power cable to a Wi-Fi in a sheltered waterproof place or box near the weather station.

Chapter 6: Fixing the Station microSD Card and Reading the microSD Card Data

MicroSD board and microSD card

A microSD card that is placed in an Adafruit microSD drive module is used to collect and record weather data from the weather station. A picture of the black microSD card which is being inserted in to the Adafruit SD board is shown in Figure 20. The microSD card costs around \$6 for an eight-gigabyte card and the Adafruit microSD board costs about \$8. Power and GND (label points) from the SparkFun Photon weather board are attached to the 5V and GND inputs of the Adafruit SD board while CLK, DO DI and CS come from the A3, A4, A5, and A2 weather board outputs. The SD module is soldered to the bottom of the SparkFun Photon weather board as shown in Figure 21. The shows how the wires connect the SD module to the weather board. The Weather Stations Technicians' Workshop Slides has instructions on how to build and solder these boards together. Chapter 10 provides information about purchasing microSD cards and the Adafruit microSD drive board. The reason Adafruit was used is that they have a fairly high reliability and also can tolerate the higher voltage, 3.7 to 3.9V. Most microSD drive boards require a 3.3V supply.

The weather station writes the data that it takes every broadcasting data cycle to the microSD card. The weather station is programmed to put data into the data card whether or not the data is being broadcast via Wi-Fi to the Weather Underground website. This timing can be every 20 seconds to every five minutes depending on how the station is programmed. This data is not lost if the weather station is powered up and working but cannot communicate via Wi-Fi. An operator or technician can open the station and pull out the data. Most weather stations don't have internal data logging capability such as this one.

Reading Data on a computer

There is an adapter with for the microSD card so it can be read by older computers. New computers can read this microSD card directly, or a microSD-to-USB converter can be used. These adapters are inexpensive and often come with the microSD cards when purchased in bulk.

The data on the SD card is readable on a spreadsheet or a text editor. The data format is a comma separated variable format (CSV) file. The presentation of the data is determined by the programming of the data recording thread in the weather station programs.

```
myFile.printf(Time.timeStr(), " ");  
myFile.printf(" ");  
myFile.printf("%0u", winddir);
```

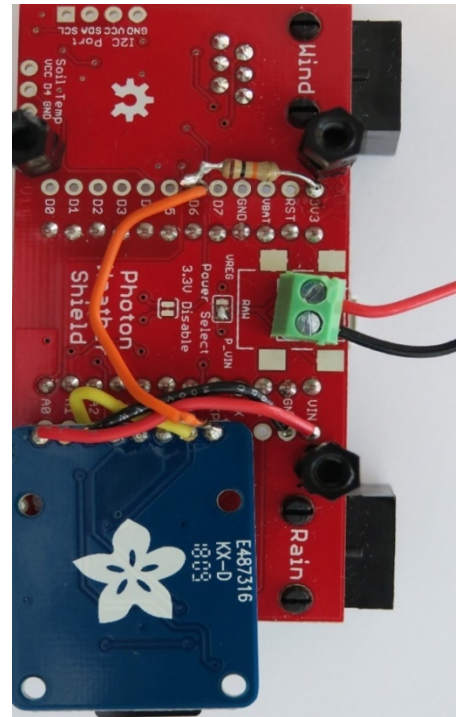


Figure 20. SD module is the blue electronic board under the red SparkFun Photon weather board.

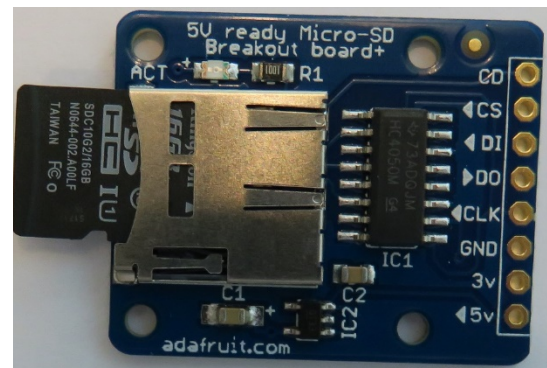


Figure 21. The SD Card partially inserted into the SD board module. The SD card is the black rectangle on the left.


```

myFile.printf("%8.6f,%6.4f,%8.6f,%8.6f,%8.6f,%8.6f,%8.6f,%8.6f,%d,%d",
windspeedmph,rainin,tempF,humidity,baroTempF,pascals/100,inches,windgustmph,solarVoltageValue,Wi-FiStrength,writeCnt);
myFile.printf("\r\n"); // Print blank line on the serial monitor port
myFile.close(); // Close the file
writeCnt++; // Increment file write counter for program monitoring

```

These lines (starts at roughly line 328 of the program) print the: 1) Time of the data measurement, 2) wind direction, 3) wind speed in mph, 4) rain in, 5) tempF, 6) humidity, 7) baroTempF, 8) pascals/100, 9) inches, 10) windgustmph, 11) solarVoltageValue, 12) Wi-FiStrength, 13) writeCnt, to the microSD drive in one line on a spreadsheet. A new spreadsheet line is printed every time the program writes data to the microSD card (every few minutes). The microSD card can hold up to 30 years of weather data. The data file on the microSD card for the weather data is “weather.txt.” This file name is easily reprogrammed. The values in this printed line are defined in the weather station software. See Chapter 8’s section on installing new station software and repairing existing station software section to identify these variables in the program.



Figure 22. microSD card and adapter for reading the card with an SD reader.

MicroSD Card Operation and Debugging

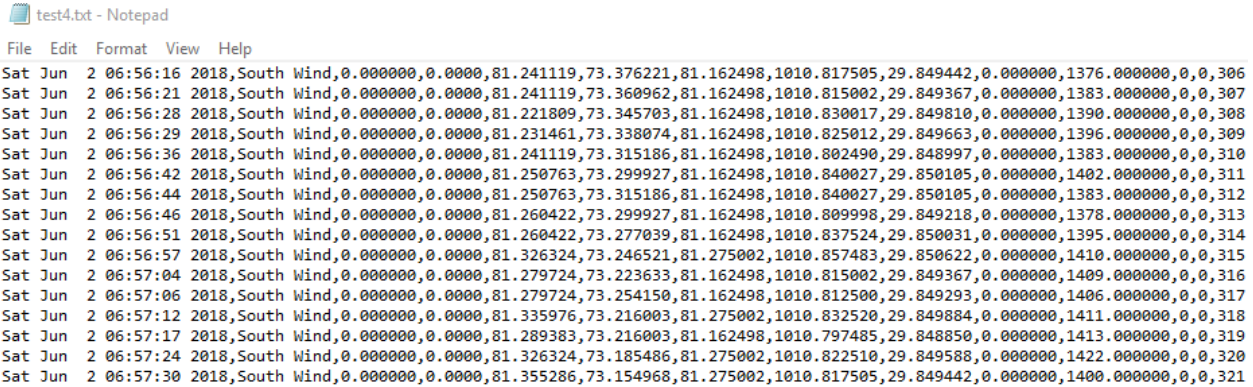
There can be a simple cause of failure of the weather station during electronics installation. This has to do with the microSD card and card reader. Quite simply, if the microSD card is missing or is not properly inserted into the microSD card reader the weather station can fail to operate properly or shut itself down. This come from the weather station code expecting to be able to write to the microSD card and getting errors when it is not there. It is unpredictable what will happen to the weather station software when the microSD card is not there, it can just stop.

When the weather station electronics box is open and the microSD card is visible, you can see a little red LED that flashes when the card reader is operating. The red LED should come on for up to 30 seconds when the weather station starts. Then it turns off. After that the microSD card should flash on for less than a second to three seconds every time the weather station writes to the SD card. If these lights are not flashing, then data is probably not read and the weather station may fail. Also, if the lights are not flashing there may be a bad microSD board or bad connections to the microSD board. A technician needs to check the microSD card data on the PC to find out. Generally, if there is a bad microSD board, it is very difficult to unsolder and replace. So, a new weather station board must be prepared.

Some of the data recorded can help debug the weather station. The time of recording is extremely useful and tells you when the weather station operating. A clearly impossible year, like “1999” from years ago, indicates that the weather station never communicated the cloud and received the proper starting time. Long breaks in the time of recording (20 minutes or more) indicate problems with the power system. The “Wi-FiStrength” data tells you Wi-Fi signal strength is maintained when the station works. Typically, this signal strength should be -75dB or greater for the station to function properly and send data to Weather Underground. The writeCnt variable tells you how many cycles the weather station has recorded data since it was started. If this number goes to zero during the weather station operation the station was reset. Having the weather station reset frequently (once a day or more) means there is a physical problem with the operation, such as weak Wi-Fi or intermittent power.

It is certainly possible to change the codes to include additional or less data on the microSD card. Unfortunately, the print command syntax, options and switches are tricky in the C language and are somewhat unpredictable when using the SDFat driver software. So, modifying the SD card programming takes time and trial-and-error work.

Some example data from a microSD drive taken a while ago is shown in Figure 23. This data does not match the variables of the printout from above since there have been changes in the code since 2018 but it does show the format. Some of the data have no values indicating that this data was test data for an electronic box indoors. This data was read by the notepad program on the PC.



```

File Edit Format View Help
Sat Jun 2 06:56:16 2018, South Wind, 0.000000, 0.0000, 81.241119, 73.376221, 81.162498, 1010.817505, 29.849442, 0.000000, 1376.000000, 0, 0, 306
Sat Jun 2 06:56:21 2018, South Wind, 0.000000, 0.0000, 81.241119, 73.360962, 81.162498, 1010.815002, 29.849367, 0.000000, 1383.000000, 0, 0, 307
Sat Jun 2 06:56:28 2018, South Wind, 0.000000, 0.0000, 81.221809, 73.345703, 81.162498, 1010.830017, 29.849810, 0.000000, 1390.000000, 0, 0, 308
Sat Jun 2 06:56:29 2018, South Wind, 0.000000, 0.0000, 81.231461, 73.338074, 81.162498, 1010.825012, 29.849663, 0.000000, 1396.000000, 0, 0, 309
Sat Jun 2 06:56:36 2018, South Wind, 0.000000, 0.0000, 81.241119, 73.315186, 81.162498, 1010.802490, 29.848997, 0.000000, 1383.000000, 0, 0, 310
Sat Jun 2 06:56:42 2018, South Wind, 0.000000, 0.0000, 81.250763, 73.299927, 81.162498, 1010.840027, 29.850105, 0.000000, 1402.000000, 0, 0, 311
Sat Jun 2 06:56:44 2018, South Wind, 0.000000, 0.0000, 81.250763, 73.315186, 81.162498, 1010.840027, 29.850105, 0.000000, 1383.000000, 0, 0, 312
Sat Jun 2 06:56:46 2018, South Wind, 0.000000, 0.0000, 81.260422, 73.299927, 81.162498, 1010.809998, 29.849218, 0.000000, 1378.000000, 0, 0, 313
Sat Jun 2 06:56:51 2018, South Wind, 0.000000, 0.0000, 81.260422, 73.277039, 81.162498, 1010.837524, 29.850031, 0.000000, 1395.000000, 0, 0, 314
Sat Jun 2 06:56:57 2018, South Wind, 0.000000, 0.0000, 81.326324, 73.246521, 81.275002, 1010.857483, 29.850622, 0.000000, 1410.000000, 0, 0, 315
Sat Jun 2 06:57:04 2018, South Wind, 0.000000, 0.0000, 81.279724, 73.223633, 81.162498, 1010.815002, 29.849367, 0.000000, 1409.000000, 0, 0, 316
Sat Jun 2 06:57:06 2018, South Wind, 0.000000, 0.0000, 81.279724, 73.254150, 81.162498, 1010.812500, 29.849293, 0.000000, 1406.000000, 0, 0, 317
Sat Jun 2 06:57:12 2018, South Wind, 0.000000, 0.0000, 81.335976, 73.216003, 81.275002, 1010.832520, 29.849884, 0.000000, 1411.000000, 0, 0, 318
Sat Jun 2 06:57:17 2018, South Wind, 0.000000, 0.0000, 81.289383, 73.216003, 81.162498, 1010.797485, 29.848850, 0.000000, 1413.000000, 0, 0, 319
Sat Jun 2 06:57:24 2018, South Wind, 0.000000, 0.0000, 81.326324, 73.185486, 81.275002, 1010.822510, 29.849588, 0.000000, 1422.000000, 0, 0, 320
Sat Jun 2 06:57:30 2018, South Wind, 0.000000, 0.0000, 81.355286, 73.154968, 81.275002, 1010.817505, 29.849442, 0.000000, 1400.000000, 0, 0, 321

```

Figure 23. Example data recorded from a microSD card using the PC notepad software.

Chapter 7: Setting Up Haiti Stations to broadcast to Weather Underground and Reading Weather Underground Archival Data

Setting Haiti Stations to Broadcast to Weather Underground

This section is about setting up the weather station software to communicate to the Weather Underground. The Weather Underground lets the public see the weather data from the weather Haiti stations given the Station web link or name. The method used in programming the weather stations is reviewed in Chapter 8: Installing new Station software and Repairing Existing Station Software. The author will review the parts of the program that need to be customized for a new or reprogrammed weather station. Also, the author will present the data that need to be entered into weather underground to establish a weather station.

The second-generation weather stations require Photon module be connected to the local Wi-Fi in order to relay data to the CRDD. It is assumed that good connections have been made (refer to Chapter 5 on Wi-Fi communications). If there are no Wi-Fi communications in place it is still possible to build a temporary weather station on Weather Underground and send data to it. This is useful for demonstrating the operation of the weather station in workshops and classrooms. This required a Wi-Fi hotspot from a cellphone. If the Wi-Fi hotspot is removed, Weather Underground will receive no more data but the microSD card will record the data.

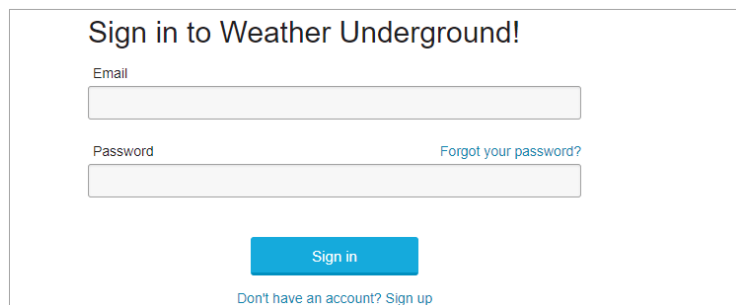
The image shows a web form titled "Sign in to Weather Underground!". It contains two input fields: "Email" and "Password". To the right of the "Password" field is a link that says "Forgot your password?". Below the input fields is a blue button labeled "Sign in". At the bottom of the form, there is a link that says "Don't have an account? Sign up".

Figure 24. Weather Underground login.

In order to introduce an new weather station or relocate an existing weather station at a new location you will have to create a new weather station on Weather Underground. The weather underground web link is: <https://www.wunderground.com>.

As part of adding a new weather station to Weather Underground it is necessary to login to the USAID AREA group Weather Underground account. The login ID can be obtained from the USAID AREA group for qualified weather technicians.

Next, the Weather Underground website will as you locate your weather station on a map. You must very carefully position your station in the proper place on the map that it will be sited. In addition, you will be asked for the altitude (elevation) of your weather station. This is from the ground level. The questionnaire also asks you for how tall your weather station is.

Personal Weather Station Network

[Overview](#)
[Buying Guide](#)
[Register with WU](#)

Step 1: Register Your Station

1. Type in the city, state, country where your weather station will be located.
2. Drag the red marker to your specific location.

Latitude: 29.573099
Longitude: -82.4076

Elevation (ft):

Height Above Ground (ft):

Verify Location →

Figure 25. Weather Underground station location on a map.

The final Weather Underground form for making your station asks about the location name, the organization and some weather station specifications.

Step 2: Tell Us About Your Station

✓ Your Location Has Been Added

Address: Gainesville, FL, 32608, US
 Elevation: 10 ft
 Height Above Ground: 5 ft
 Lat, Lon: 29.573089, -82.4078
 Time Zone: America/New_York

Fill out the additional information about your weather station:

Neighborhood: (required)
 e.g. Pacifica Sea Cliffs - required

Organization:

Website:
 name
 URL

MADIS ID:

Station Hardware: (required)
 -- Select a Station --

Surface Type:
 rooftop (composite-shingles)



Associated WebCam:


PWS Notification Email Preferences:
☒ I would like to receive PWS notifications
☐ I would like to receive PWS community newsletter

[← Back](#) [Submit →](#)


Figure 26. Weather station description details.

After you have completed your weather station description, Weather Underground will give you a new weather Station ID and a weather Station Key. Below is a Station ID and Key for Kenscoff.


Kenscoff




25.3 °C
Clear


 Station ID: **IKENSCOF3**
 Station Key: **6r0kf453**

Kenscoff, HT

[Status Message](#) | [Get Weather Sticker](#)

Figure 27. Example Station ID and Key provided by Weather Underground.

```

189 retained char ID [] = "KFLGAINE114"; //Home Station
190 retained char PASSWORD [] = "1zh4x146"; //Home Station PW

```

Figure 28. Original weather station Weather Underground ID and password.

The weather station program for a particular station must be modified to include this information. One can modify the Haiti_Cloud_RTC program by changing the name to the CRDD name and by changing two lines in the program.

```

189 retained char ID [] = "IKENSCOF3"; //Kenscoff CRDD station
190 retained char PASSWORD [] = "6r0kf453"; //Station PW

```

Figure 29. Modified Station ID and password.

Fixing the Weather Underground Communications

Weather Underground will accept data fairly reliably once the communications are established. At the start of a new weather station broadcasts or if a weather station has been offline often, Weather Underground will wait 20 minutes before posting weather data on its graphs. So, it can appear everything is working correctly but a technician cannot confirm with Weather Underground immediately.

If Weather Underground does not report data after 20 minutes of operation then the issues could be 1) the Wi-Fi connection, 2) the station description in the weather program or 3) the method of data communication to weather underground. (Refer to Chapter 5, Fixing the Wi-Fi Communications to establish a good Wi-Fi connection.) Check the SSID and the password in the weather station program to make sure they are correct so Weather Underground will take the data. Finally, in the code there is a web address to the Weather Underground rapid fire server. This was programmed in because it works and the standard server code line does not work and has been commented out. So, change the code to use the rapid fire server if someone has mistakenly modified this.

```
184 retained char SERVER[] = "rtupdate.wunderground.com"; //Rapidfire update server - for multiple sends per minute
```

Download data from Weather Underground

The lack of easily accessible Weather Underground website documentation makes it somewhat difficult to find archival data from weather stations. The author uses these weblinks to help download archival data:

- <https://ambientweather.net/help/how-do-i-download-data-from-weatherunderground-com/>
- <http://www.meteor.iastate.edu/~slincoln/stationdata/>
- <https://docs.google.com/document/d/1w8jbqfAk0tfZS5P7hYnar1JiitM0gQZB-clxDfG3aD0/edit>
- https://feedback.weather.com/?b_id=17298#ask
- https://docs.google.com/document/d/1eKCnKXI9xnoMGRRzOL1xPCBihNV2rOet08qpE_gArAY/edit

Chapter 8: Installing new Station software and Repairing Existing Station Software

Web links for Programming information

Below are web links and references which will help in learning how to program the weather station Photon processor module. It is assumed that the weather station technician has some experience at this so these links are here for reference.

- [Particle IDE for programming](#)
- [Particle App for the phone](#)
- [Particle Documentation](#)
- [Particle Store](#)
- [Particle Community](#)
- [Reference Book on Particle programming](#)

Before at Photon module must be “captured” and put onto a Photon account before it can be programmed with weather station software using the Particle IDE as described below. This process is described in the Weather Station Technicians’ Workshop Slides.

Weather Station Software Flow Chart

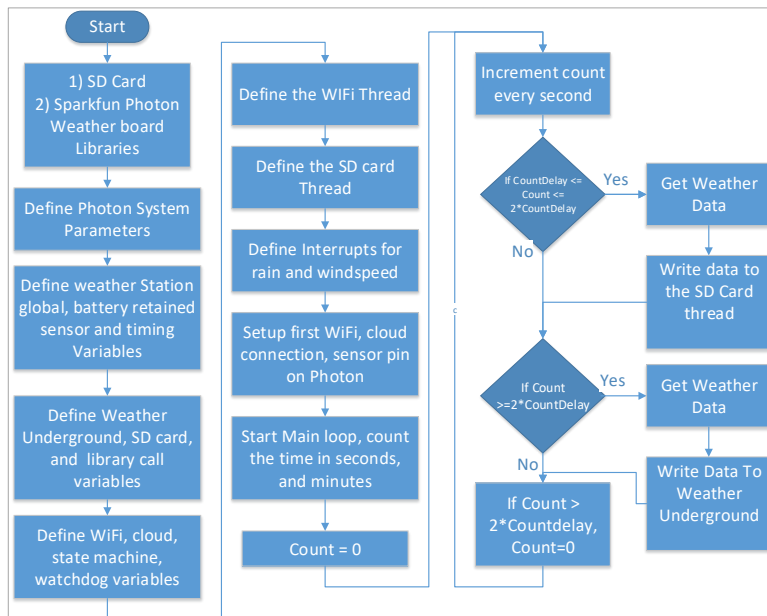


Figure 30. Weather station software flow chart.

This section will walk through the software flowchart for the weather station. Then, how to install the weather station is presented. A description about how to modify and debug the code follows. The built-in code testing using the PC is shown and final the software and data exchange on the particle cloud is reviewed. The software block diagram is shown in **Error! Reference source not found.**

The Particle Photon software first installs the SD card libraries, the weather station libraries, defines the variables used to run the weather station program and the Wi-Fi communications variables. The software sets up three program threads that run concurrently, an instrumentation and data measurement main program, a thread that runs the Wi-Fi communications and a thread that writes to the SD card. Interrupt routines are set so that the rain and wind gauges record data when there is rain or wind. An initial connection to the Wi-Fi and the particle cloud is made. This initial connection downloads the current time into the weather station and the weather station keeps accurate future time using a real time clock. The Wi-Fi connection is turned off to battery save power. Then, the weather station starts is big data collection and reporting loop. A programmer defined variable called Countdelay, (in seconds) determines the cycle time of weather data reporting. The cycle time “count” starts a zero seconds and counts up to 2*Countdelay after which “count” is set back to zero and the counting continues. At “count” equals Countdelay seconds the weather station starts the SD card thread writes the weather variables to the SD card and then exits the thread. After “count” equals 2* Countdelay, the weather station connects to the Wi-Fi and sends data to the weather underground and then turns off the Wi-Fi when complete to save power. The main program continually monitors and updates the weather information.

Weather Station Programming on Particle IDE

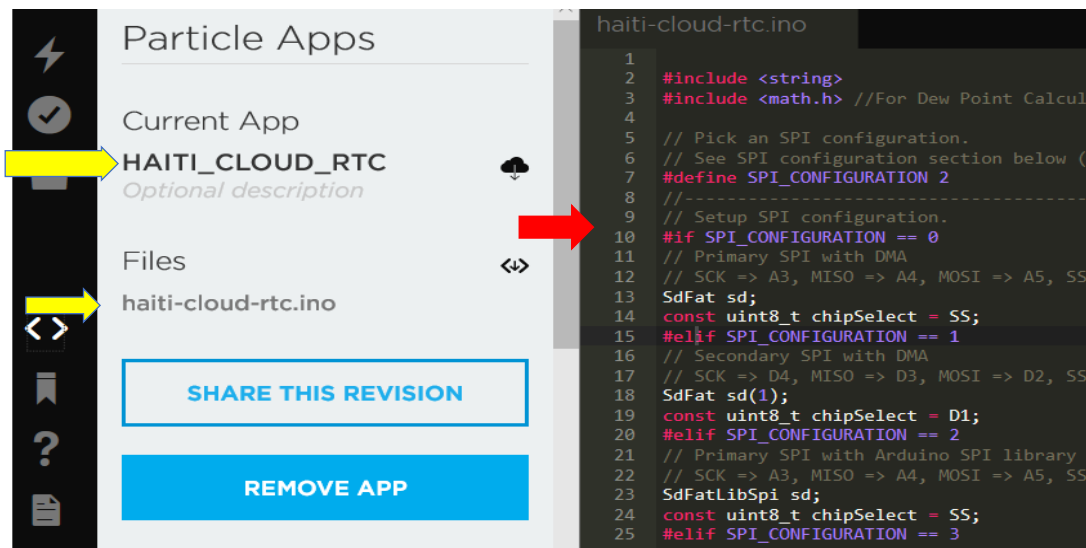


Figure 31. The Haiti_Cloud_RTC for station programming.

The weather station is programmed through the Particle IDE online which has programming support, tutorials and a programming community forum [19]. In order to use this software to program the weather station Photon processor module it is necessary to set up an account and password on the Particle Industries' website.

The HAITI_CLOUD_RTC program is the template program for all the Haiti weather stations installed by AREA. Press the “<>” marking on the Particle IDE to see the weather station programs in Figure 31. You can save this program under a new name to create a new weather station program. The scroll in the middle of Figure 31 (see red arrow) must be pulled down and “Create new App” pressed, a new name must be entered under current app. Then the app must be saved by pressing the folder icon.

Press the ribbon icon for the libraries and search for the SparkFun_Photon_Weather_Shield_Library. Press type the project name you are working on and press “Include in Project,” Figure 33. Then, confirm that you want to install the library in that project. The SDFAT library is more difficult to install because you need to install version 0.0.7 for it to be compatible with the SD card and compile properly. The next series of illustrations show how to install the SDFat library.

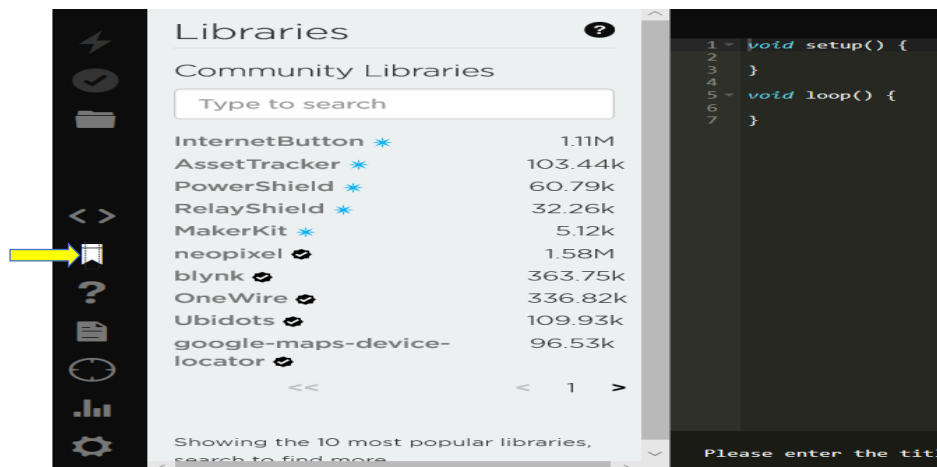


Figure 32. Yellow icon arrow causes the program to go to Libraries.

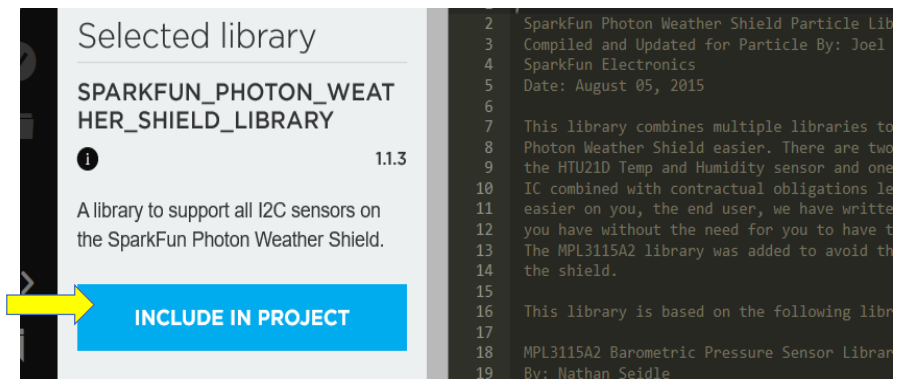


Figure 33. Include a library in a Project.

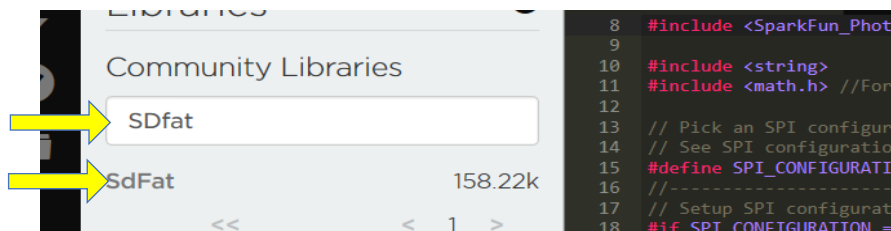


Figure 34. Installing SDFAT library, first find the library on the cloud.

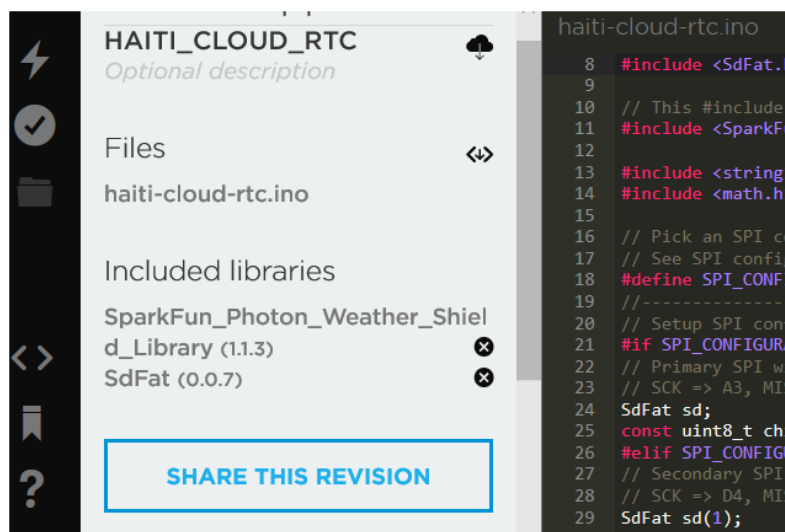


Figure 36. The SDFAT libraries and the SparkFun libraries are now included in haiti_cloud_rtc.

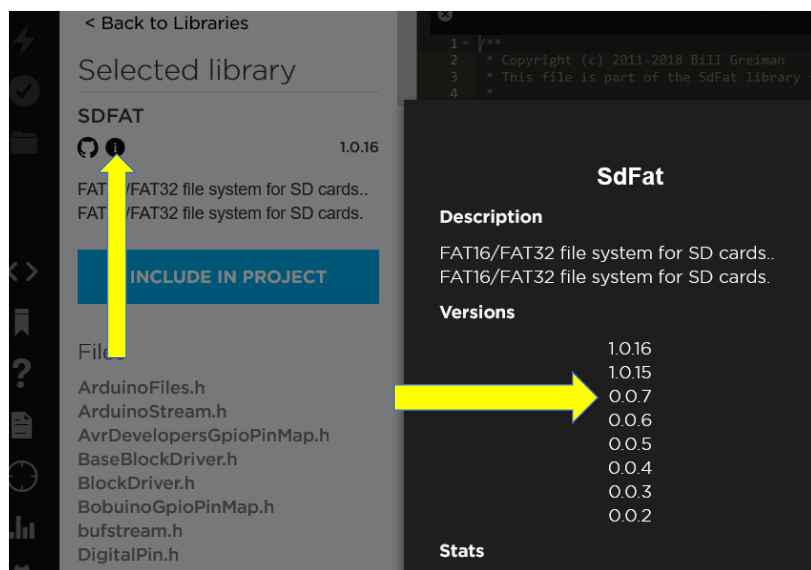


Figure 35. It is necessary to use version 0.0.7 of the SD FAT software to compile in the program.

It will often be necessary to modify the code of the new weather station. In particular, the weather station technician may want to add capability or change the weather station timing and reporting. Change and update the weather station password. Turn on or off the weather underground broadcast and put the station into test mode in order to debug the weather station.

The first thing to do is to add the proper libraries as just shown in this section. The code will not compile on the Particle IDE unless the proper libraries are included. Then, the particle IDE must identify a particle Photon device as a target for the code. The particle IDE keeps track of the Photon devices and what version of operating system are installed. If the IDE does not have an identified Photon device, it may behave strangely and not compile code. Figure 37 shows the SDFat library included in the photon code.

The last two illustrations show that the programmer must press the circle (large yellow arrow) to identify all the Photon devices available and then pick a particular Photon device (thin yellow arrow). The Photon device needs to be connected to the cloud in order to program it..

Next, verify the code by pushing the verify check in Figure 38. This will tell the programmer that the code can be compiled properly and also saves the latest version of the code. After that the new weather station code can be installed on the Photon device using the compile and install button which is the thunderbolt under the red arrow. See Figure 38 below to verify and compile the code.

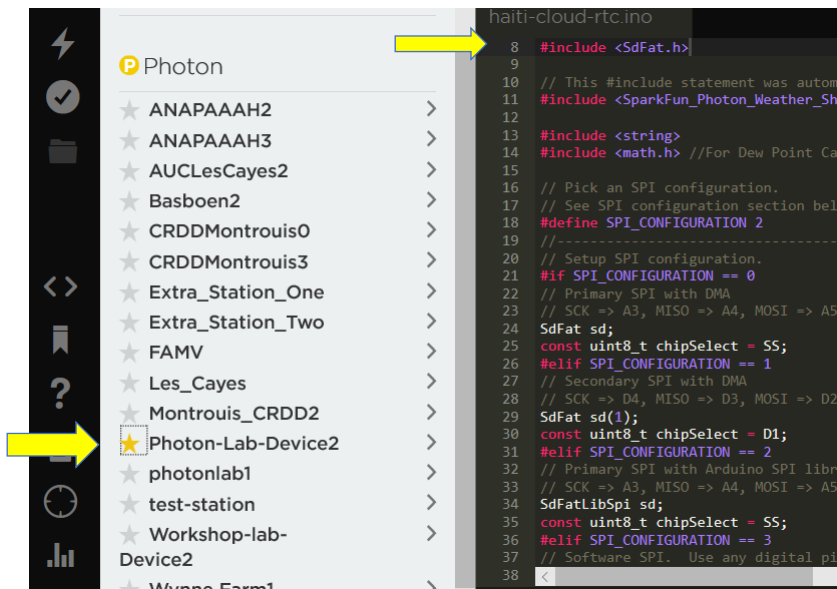


Figure 37. Shows the particle photon named Photon-Lab-Device2 is being programmed with SDFat libraries.

The code verification or compile will come back with a statement “Code verified. Great work!” if the code compiles and is ready to go. If you push the symbol of the exclamation mark surrounded by a circle the compiler will show you the flash and ram used during verification or compilation.

There are many reasons why the code will not verify or compile. Here is a checklist of things to look at if there are compiler errors. It is also important to click on the compiler errors and get more detail about the problems. The errors will tell you the line number or the subroutine at which the error is encountered.

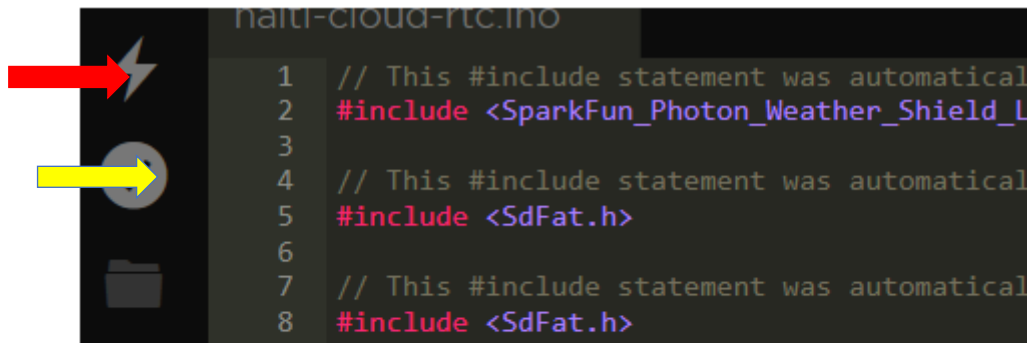


Figure 38. Verify button on the Particle IDE, yellow arrow. Compile button on the Particle IDE, red arrow.

Common coding errors caught by the particle IDE

- There is no device assigned for verification on compilation. If there is no device name in the lower right corner of the screen. Look for the yellow dot next to device name
- The device selected is not communicating via the particle cloud and does not receive the code. Look for the indicator at the bottom right of the IDE bar be filled in and flashing or solid.
- There is an error in the code that refers to a subroutine, Such as SDFAT, or SparkFun weather station drivers. Make sure the libraries SDFAT and SparkFun_Photon_Weather_Station are included in the main program.
- There is an error in the c code lines of the program not part of the subroutines. Make sure the variables are properly declared. The verification is case sensitive and if you change the capitalization form CountDelay to countDelay you have a new variable. Every variable, and subroutine in the program needs a proper declaration before it is used.
- There are other syntax errors in compilation of general c code that are not variable declarations. You are going to have to work through the code and find the problem.
- There are errors in compilation of the code statements specific to the particle IDE compiler. You need to go into the particle IDE tutorials and look up the syntax of these code statements. An example would be the instruction, STARTUP (Wi-Fi.selectAntenna(ANT_EXTERNAL)); which selects the external antenna on the weather station and has to have this specific syntax.

Testing the Weather Station Instruments with Software

There is special test software installed in the Haiti_Cloud_RTC software that all you to see the weather station instrument response. In order to see the response on a computer you have to install a Serial Port monitor on a computer. Then, you can connect the computer to the serial input port of the weather station processor and watch the software cycle through the Photon processor. In addition, you can see of the software communicates via Wi-Fi to weather underground and also to the microSD Card. This requires a USB to microUSB cable to connect between the PC USB port and the Photon processor microUSB port. MicroUSB is one of the stand USB ports; there are USB, miniUSB and microUSB cables and connectors. MicroUSB are used for charging and connecting to Android cell phones and Photon processor modules. See the Section Chapter 10: Weather Station Bill of Materials, as of July 2019, for the price of a USB to microUSB cable.

In order to do these communications, you need to install a serial monitor program. Putty is a good free program to do this, <https://www.putty.org>. The Putty app is shown below.

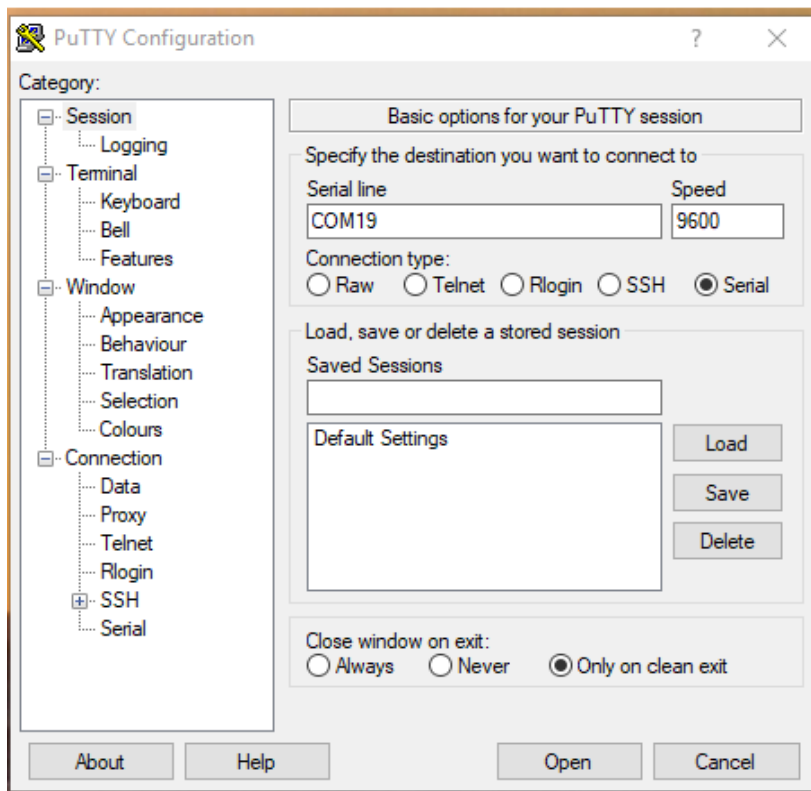


Figure 39. The Putty Software GUI

When using the Putty program, you should be connected between the computer and the Photon module using the USB cable. In order to connect properly you need to be connected in serial mode (Figure 39). Start with 9600 baud, this will be adjusted by Putty and you need to enter the correct serial line. Figure 39 shows COM19 (but each connection is different).

One way to find the serial line (COM xx port) that is connected on the computer is to use the device manager. Type Device Manager into the search box in the left part of the windows toolbar at the bottom of your screen and press enter. A device manager window will pop up. Then click on Ports (COM & LPT). The device manager will show you what COM port is active. In the illustration below, COM 19 is active. Then COM19 is entered into the Putty user's interface serial line. Then press the Open key.

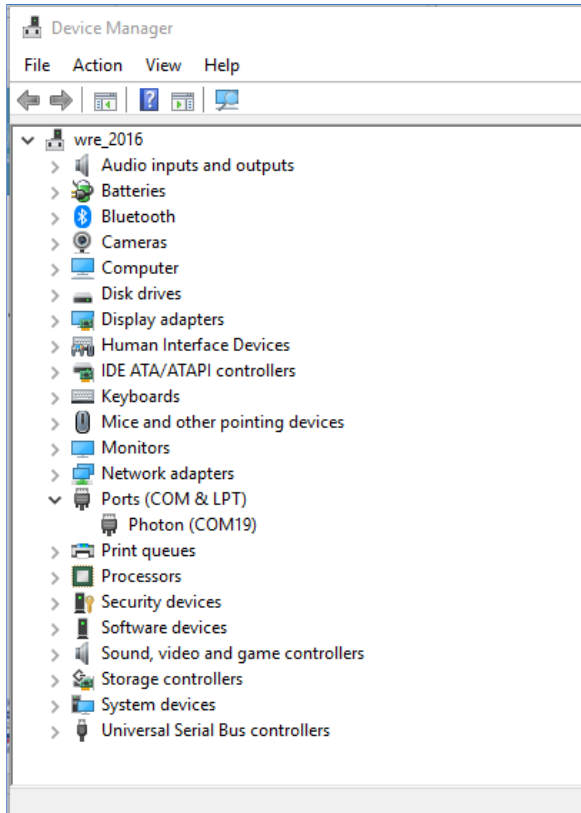


Figure 40. Windows Device Manager showing COM19 Serial port.

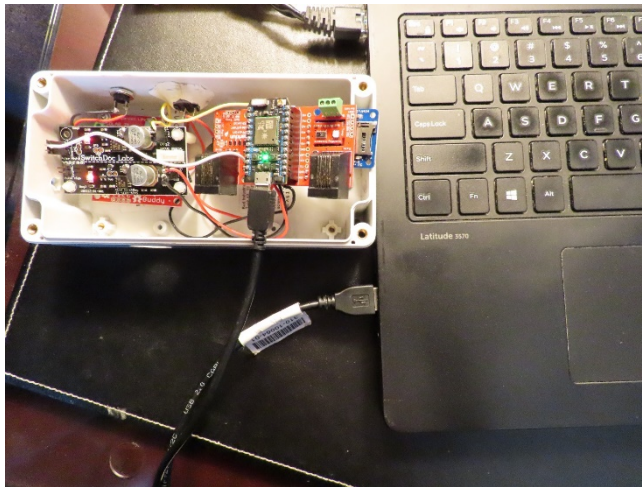


Figure 41. Serial port connection between PC and weather station.

After everything is connected, the Putty user interface will put out a serial connection window as shown below. But not much will be shown. That is until you put the weather station program into test mode where all the information of weather station is reported. To put the weather station into test mode you need to program the weather station. Look around line 220 in the program. You need to find the line that says:

Volatile int testMode=0; and change the line to Volatile int testMode=1;

FYI, to find a line using the Particle IDE you can use a search mode. The easy way to do this is to press Control F and enter what you want to find into the search box.

Now, with `testMode=1`, the weather station processor will report, the start of the program, and data every second the program works. It will report when it writes to the SD card and when it writes to Wi-Fi. You can look through the program and look at the print statements. These report output to the serial port when the program is in test mode. You can search through the program for “Print” and see all the information that will be printed in test mode. Figure 47 shows the serial monitor window of Putty. If the station is working, there should be something coming up on this window roughly every second. It will also report connections to the SD card, to weather underground, to the particle cloud and the weather station sensor output. The date and time should be correct in the data too.

A potential cause of failure can be leaving the weather station in `testMode = 1`. The Weather station code requires `testMode = 1` to enable data transmission to Weather Underground. You can see the Chapter about programming to help fix this. The important program line at the time of writing this document was: *212 `volatile int testMode=0; // sets up serial printout and turns off WU delivery for test mode when true, testMode = 1.`*

Make sure `testMode = 0` when you compile and load the final weather station program.

Chapter 9: Summary and Future Directions

This manual has been the culmination of several years of work on developing the second-generation Haiti Photon weather stations and testing them in the field. There are significant issues with keeping the weather stations working in Haiti due to the environment and the infrastructure. This manual is an effort to provide a knowledgeable technical person with the tools to fix broken weather stations and maintain the software. This manual requires access to the Weather Station Technicians' Workshop Slides (the URL to access those again is: <http://bit.ly/weather-station-slides>) for a complete picture of how to build and maintain the Haitian second-generation weather stations.

Like all internet-of-things devices, the Haiti second-generation weather stations are subject to a large amount of change in their software coding environment and in their sensors. Many of the sensors and parts can go obsolete or be unobtainable at future dates. So, the parts and sensors will have to be upgraded. In addition, the basic processors of the weather station the Particle Photon has been upgraded to the Particle Argon with more capability in newer IoT systems. It takes a continuous effort to keep these weather stations current both in hardware and software so they are compatible with the latest upgrades.

The Haiti weather station system spans a large gamut of solar power, weather sensors, embedded software, wireless communications, and cloud databases. By, learning about and working with these weather stations any engineer or scientist can greatly improve their knowledge of what is going on in the IoT revolution. It is my hope that the manual users learn about these systems and greatly improve their capability and careers in doing so.

Chapter 10: Weather Station Bill of Materials, as of July 2019

The following table shows the bill of materials necessary to buy parts to build four second-generation weather stations. It is recommended that an inventory of spare parts be kept for repair of stations.

Components	Vendor	Part link	Retail Cost \$	Number of parts	Total Cost \$
Particle Photon	SparkFun or Amazon	https://www.SparkFun.com/products/13774	19.00	4	76
SparkFun Photon Weather Shield	Spark Fun	https://www.SparkFun.com/products/13674	34.95	4	139.8
SD breakout board	Amazon (free shipping) Digikey and Ada Fruit	https://www.digikey.com/product-detail/en/254/1528-1462-ND/5761230	7.50	4	30
8 GB microSDHC Class 4 flash memory card SDC4	Amazon	https://www.amazon.com/gp/product/B00200K1TS/ref=ox_sc_act_title_1?smid=ATVPDKIKX0DER&psc=1	3.38	4	13.52
Clear Bud Boxes, waterproof enclosure	Digikey, Amazon	https://www.digikey.com/product-detail/en/bud-industries/PN-1332-C/377-1133-ND/387052	15.70	4	62.8
Sunny Buddy boards	Digikey, SparkFun	https://www.digikey.com/product-detail/en/PRT-12885/1568-1291-ND/5762441/?itemSeq=296356102	26.95	4	107.8
6V 6 W solar panel	SparkFun, AdaFruit	https://www.SparkFun.com/products/13783	59	4	236.0
SwitchDoc Labs watchdog timer, also for upgrading existing stations	Amazon	https://www.amazon.com/SwitchDoc-Labs-WatchDog-Arduino-Raspberry/dp/B00OL1N7R2/ref=sr_1_1?keywords=dual+watchdog+timer&qid=1561490648&s=electronics&sr=1-1&qty=4	15.95	4	63.8
2 package antennas, high gain Wi-Fi	Amazon	https://www.amazon.com/gp/product/B01GMBUS8O/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1&qty=2&selectObb=b2bNew	9.59	2	19.18
3.7 6000mAh lithium battery	SparkFun, Amazon, Adafruit	https://www.SparkFun.com/products/13856	29.95	4	119.8
Button coin cell battery holder, 10 pack	Amazon	https://www.amazon.com/gp/product/B07DB3FQ1H/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1	4.99	1	4.99
Coin cell batteries CR 2032, 5 pack	Amazon	https://www.amazon.com/gp/product/B00K62Y2O2/ref=ox_sc_act_title_1?smid=A3BE7YTVCPK9BY&psc=1	3.99	1	3.99

220PCS M3 nylon spacers for boards, assorted	Amazon	https://www.amazon.com/dp/B073XZ3H4M/ref=sspa_dk_detail_2?psc=1&pd_rd_i=B073XZ3H4M&pd_rd_w=1yGgy&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=FG5Ni&pf_rd_r=VKFY4GDQDNGSFNRXR8H&pd_rd_r=456fa866-9789-11e9-b500-9959ee5ce66b	11.99	1	11.99
22 AWG hook up wire, solid core	Amazon	https://www.amazon.com/gp/product/B077HRKYB1/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1	14.99	1	14.99
Breakaway PCB Board 40Pin 2.54mm male and female header connector for Arduino shield	Amazon	https://www.amazon.com/UEETEK-Breakaway-2-54mm-Connector-Arduino/dp/B075XLYZKW/ref=pd_day0_hl_201_8?encoding=UTF8&pd_rd_i=B075XLYZKW&pd_rd_r=c0efad91-981c-11e9-9ae5-454ccedf7fa2&pd_rd_w=Wtvec&pd_rd_wg=ChPTj&pf_rd_p=ad07871c-e646-4161-82c7-5ed0d4c85b07&pf_rd_r=BWF1P02JFCP26H1QE46Z&psc=1&refRID=BWF1P02JFCP26H1QE46Z	5.15	1	5.15
2.1mm x5.5mm 2 Pins DC power jack female panel mounting connector socket	Amazon	https://www.amazon.com/URBEST-x5-5mm-Female-Mounting-Connector/dp/B01M1D5GIP/ref=cm_cr_a_rp_d_product_sims?ie=UTF8	7.99	1	7.99
Weather wind and rain instruments	Argent Data	https://www.argentdata.com/catalog/product_info.php?products_id=145	79.00	4	316
Ambient weather shield SRS100LX	Ambient	https://www.ambientweather.com/amwesrptean.html	49.99	4	199.96
0.1uF 50V low voltage ceramic disc capacitors	Amazon	https://www.amazon.com/Uxcell-a11092900ux0135-Voltage-Ceramic-Capacitor/dp/B010SENUPE/ref=pd_rhf_s_e_s_vtp ses_clicks_shared_0_1/135-1687331-3976811?encoding=UTF8&pd_rd_i=B010SENUPE&pd_rd_r=111f5547-a715-4187-9283-bbe3466591f2&pd_rd_w=JvHdb&pd_rd_wg=LTnzV&pf_rd_p=fc133098-0fe0-425e-be82-4e2e411bf8ca&pf_rd_r=FT774D9XKZ17Q81X5R91&psc=1&refRID=FT774D9XKZ17Q81X5R91	6.08	1	6.08
3.5mm pitch 2Pin PCB mount screw terminal block connector	Amazon	https://www.amazon.com/uxcell-3-5mm-Pitch-Terminal-Connector/dp/B00R1M0CBM/ref=pd_cp_23_2?pd_rd_w=HjtIw&pf_rd_p=ef4dc990-a9ca-4945-ae0b-f8d549198ed6&pf_rd_r=QZSM4BXAP78NBB8M98SM&pd_rd_r=3dc90e8c-9821-11e9-bc14-57128b8bcbf3&pd_rd_wg=9EBey&pd_rd_i=B00R1M0CBM&psc=1&refRID=QZSM4BXAP78NBB8M98SM	8.21	1	8.21

40pcs (8 Kinds) 2.54/3.8/5.0/7.5mm Pitch 2/3 Pin PCB mount screw terminal block connector assortment kit	Amazon	https://www.amazon.com/s?k=40pcs%288+Kinds%29+2.54%2F3.8%2F5.0%2F7.5mm+Pitch+2%2F3+Pin+PCB+Mount+Screw+Terminal+Block+Connector+Assortment+Kit&i=electronics&ref=nb_sb_noss	12.99	1	12.99
Misc. hardware and shipping					120
Total cost					\$1,581

Useful tools for Maintaining and Building Weather Stations as of July 2019

These are useful tools second-generation weather station workstation maintenance for a team of 4 weather station technicians. These are example good tools and others may be substituted.

Component(s)	Vendor	Link	Retail Cost \$	Number of parts	Total Cost \$
3 pack USB to microUSB cable	Amazon, Spark Fun	https://www.amazon.com/gp/product/B07211BSV6/ref=ox_sc_act_title_1?smid=A2Q1LRYTXHYQ2K&psc=1	7	2	14
Box Cutter Utility Knife (6 PACK) Retractable Razor Blades Knives with Snap-Blade and Slide Lock	Amazon	https://www.amazon.com/Utility-Retractable-Snap-Blade-Replacement-Included/dp/B01N7Q7ROC/ref=sr_1_31?keywords=Utility+knives&qid=1561561250&s=gateway&sr=8-31	7.99	1	7.99
450pcs (5 Colors x 90pcs) 5mm LED Light Emitting Diode Round Assorted Color White/Red/Yellow/Green/Blue Kit Box	Amazon	https://www.amazon.com/DiCUNO-450pcs-Colors-Emitting-Assorted/dp/B073QMYKDM/ref=sr_1_4?keywords=led+kit&qid=1561561443&s=gateway&sr=8-4	12.99	1	12.99
Kuman for Arduino Raspberry pi, 5PCS Soil Moisture Sensor Module and 5 PCS Temperature Humidity Sensor	Amazon	https://www.amazon.com/Arduino-Raspberry-Moisture-Temperature-Humidity/dp/B071NX3234/ref=sr_1_fkmr0_1?keywords=kuman+5+pcs+soil+moisture+sensor+kit&qid=1561561580&s=gateway&sr=8-1-fkmr0	16.98	1	16.98
(4 Pcs) MCIGICM 400 Points Solderless Breadboard	Amazon	https://www.amazon.com/gp/product/B07PCJP9DY/ref=ox_sc_act_title_1?smid=ATHZ0BI0D2RLH&psc=1	7.86	1	7.86
Maximm Cable Electrical Wire Stripper, Cutter and Plier, [4 Pack]	Amazon	https://www.amazon.com/Maximm-Electrical-Multi-Function-Precision-Threading/dp/B07FNTNGYH/ref=sr_1_1?keywords=Maximm+Cable+Electrical+Wire+Stripper%2C+Cutter+And+Plier%2C+%5B4+Pack%5D&qid=1561561797&s=industrial&sr=1-1	19.29	1	19.29
#2 Phillips head screwdriver	Lowe's	https://www.lowes.com/pd/project-source-2-phillips-screwdriver/50158857?cm_mmc=shp_-c_-prd_-tol_-google_-lia_-216_-screwdrivers_-50158857_-0&kpid&store_code=2365&k_clickID=go_1736136440_69711721402_338438680003_pla-393988830637_c_9011698&gclid=EAIaIQobChMIoY3Gro6r4wIVCl8NCh0akQAQYAIAABEgISB_D_BwE	1.18	4	4.72

Mini Needle Nose Pliers Multifunction	Amazon	https://www.amazon.com/Multifunction-Precision-Stripper-Jewellery-Beading/dp/B0797KMMLP/ref=sr_1_3?keywords=Mini+Needle+Nose+Pliers+Multifunction&qid=1561561892&s=gateway&sr=8-3	4.99	4	19.96
Electrical tape	Amazon	https://www.amazon.com/Scotch-Super-Vinyl-Electrical-Tape/dp/B00004WCCL/ref=sr_1_5?keywords=electrical+tape+for+outdoor&qid=1562719193&s=gateway&sr=8-5	3.98	1	3.98
Resistor assortment kit	Amazon	https://www.amazon.com/dp/B07L851T3V/ref=spsa_dk_detail_5?psc=1&pd_rd_i=B07L851T3V&pd_rd_w=FadXh&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=0T0ky&pf_rd_r=HXS4A53KRB93CW4V4XBP&pd_rd_r=dd9be779-a2ab-11e9-b055-c790120e382f#customerReviews	11.95	1	11.95
Soldering Station	Amazon	https://www.amazon.com/Hakko-FX888D-23BY-Digital-Soldering-Station/dp/B00ANZRT4M/ref=sr_1_3?keywords=Hakko+Digital+Soldering+Station+Review&qid=1562720045&s=gateway&sr=8-3#customerReviews	99.42	4	397.68
Solder	Amazon	https://www.amazon.com/dp/B07BGTSWYB/ref=spsa_dk_detail_1?psc=1&pd_rd_i=B07BGTSWYB&pd_rd_w=rFbUR&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=z9Aln&pf_rd_r=01Z0Y6FGKH7H96SRFQ82&pd_rd_r=b5e18bf4-a2ad-11e9-a9ae-270e3ef58a57#customerReviews	10.59	1	10.59
solder wick and solder sucker	Amazon	https://www.amazon.com/dp/B0777LMVTT/ref=spsa_dk_detail_4?psc=1&pd_rd_i=B0777LMVTT&pd_rd_w=s2i2L&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=5vFRi&pf_rd_r=80DZ1QHTR7EQHVWJEWJC3&pd_rd_r=090045df-a2af-11e9-a93c-6bb543d57023	8.98	1	8.98
Soldering Iron Tip Cleaner	Amazon	https://www.amazon.com/dp/B00J66FSY2/ref=psdc_13837401_t3_B07FYJC3DF	6.89	4	27.56
Solder iron tip tinner	Amazon	https://www.amazon.com/Thermaltronics-FBA-TMT-TC-2-Lead-Tinner-Container/dp/B00NS4J6BY/ref=pd_bxgy_469_2/144-6115037-2101436?encoding=UTF8&pd_rd_i=B00NS4J6BY&pd_rd_r=10394050-a34c-11e9-ae2b-152fe49d8d51&pd_rd_w=1ig4E&pd_rd_wg=Rxjj4&pf_rd_p=a2006322-0bc0-4db9-a08e-d168c18ce6f0&pf_rd_r=1CYBQA2THRF0WP1DPV5&psc=1&refRID=1CYBQA2THRF0WP1DPV5	6.5	1	6.5

12 pack of Safety glasses	Amazon	https://www.amazon.com/JORESTECH-Eyewear-Protective-Polycarbonate-Resistant/dp/B01KGJTAQ4/ref=sr_1_3?crid=2V5D4V37PUNUU&keywords=safety+glasses&qid=1562720379&s=gateway&srefix=safe%2Ctools%2C187&sr=8-3	11.30	1	11.3
Magnifying stand	Amazon	https://www.amazon.com/Delixike-Magnifying-Glass-Reading-Repair/dp/B07PSNV812/ref=sr_1_8?crid=25O41U9UKYV5Z&keywords=magnifying+stand+for+close+work&qid=1562720687&s=gateway&srefix=magnifying+stand%2Caps%2C153&sr=8-8	37.99	1	37.99
Third hand soldering tool	Amazon	https://www.amazon.com/dp/B0777LMVTT/ref=sspa_dk_detail_4?psc=1&pd_rd_i=B0777LMVTT&pd_rd_w=s2i2L&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=5vFRi&pf_rd_r=80DZ1QHTR7EQHVWJEW3&pd_rd_r=090045dfa2af-11e9-a93c-6bb543d57023	7.01	4	28.04
AstroAI Digital Multimeter	Amazon	https://www.amazon.com/gp/product/B01ISAMUA6/ref=ox_sc_act_title_1?smid=A2NOFZGOKNP3PJ&psc=1	10.88	4	43.52
KOOTION 10pcs 8GB USB 2.0 Flash Drive Memory Stick Thumb Storage Pen Disk	Amazon	https://www.amazon.com/Flash-Drive-Capped-Memory-Kootion/dp/B00U3GXAIA/ref=sr_1_2?keywords=10%2BX%2BMOSDART%2B4GB%2BUSB2.0%2BBulk%2BFlash%2BDrives&qid=1561562121&s=hi&sr=8-2&th=1	26.8	1	26.8
5pack microSD reader adapter	Amazon	https://www.amazon.com/gp/product/B07BP7CNSQ/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1	4.88	1	4.88

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