



DIFFRACTION LIMITED

Boltwood Cloud Sensor III

User's Manual

Version 1.5 – June 28, 2023

FCC Compliance Statement

This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the receiver and the equipment.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.
- Use shielded I/O cables when operating this equipment.
- You are also warned that any changes to this certified device will void your legal right to operate it.

Contains FCC 2AC7Z-ESP32WROOM32E

Industry Canada Compliance Statement

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

Contains IC 21098-ESPWROOM32E

European Union

This product is in conformity with the protection requirements of EU Council Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility. This product has been tested and found to comply with the limits for Class B Information Technology Equipment according to European Standard EN 55022. The limits for Class B equipment were derived for typical residential environments to provide reasonable protection against interference with licensed communication devices.

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Warnings

THIS DEVICE IS PRIMARILY INTENDED FOR OBSERVATION PLANNING. While it can be used to trigger the closure of an observatory under adverse weather conditions, it is NOT intended as the primary or sole protection against wind, rain or snow entering the observatory. Under certain meteorological conditions it is possible for rain to occur without clouds being detected by the sensor. Significant rainfall or snowfall may occur before the wetness detector triggers. Improper installation or adjustment may impair detection of adverse weather conditions. Operator vigilance and the use of multiple weather information sources are essential when operating an observatory remotely.

THE SENSORS CAN GET HOT. Depending on ambient conditions, the wind sensor can reach 70°C (158°F). The rain sensor is also heated and can achieve 60°C (148°F). The thermopile sensor is also gently heated to prevent dew/frost.

THE ROOF CLOSURE CONNECTOR CAN ACTIVATE AT ANY TIME. When working on your observatory or the cloud sensor unit, we recommend either unplugging the roof close connector or powering down the dome system.

DO NOT EXPOSE YOUR SENSOR TO CORROSIVE CONDITIONS. Industrial pollution, salt spray, etc., can damage the sensor. Salt spray can occur 30 kilometers inland.

BE CAREFUL WITH THE ANTI-BIRD WIRES. They could potentially cause injury if accidentally contacted. They will not hurt a bird as they will simply get poked in their underside and fly away. We recommend they be installed only if the sensor is mounted out of reach.

INSTALL AND OPERATE ACCORDING TO THE INSTRUCTIONS. The sensor is intended for outdoor use, but not water immersion. The sensor should be powered continuously while outdoors, to allow the heaters to prevent moisture accumulation.

Please read this entire manual carefully prior to installation and operation of the equipment.

NOTE:

The new Boltwood Cloud Sensor III uses a new generation of sensors, improving upon the prior generation of Boltwood Cloud Sensor II. It also adds new capabilities that were not available on earlier models. Unlike the older models, these units use new software, including the current state-of-the-art ASCOM Alpaca technology for Safety Monitoring and Observing Conditions. This is not compatible with the old software that came with the Boltwood Cloud Sensor II. Contact Diffraction Limited Technical Support if you require assistance configuring your new cloud sensor.

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1 – The Boltwood Cloud Sensor III

The Boltwood Cloud Sensor III is a weather monitoring device for astronomical observatories. The sensor can detect the following:

- Clouds
- Rain drops
- Wet snow
- Wind speed
- Temperature
- Humidity
- Dew Point
- Barometric Pressure
- Daylight
- Power Supply Voltage

The primary sensors used for determining safe/unsafe observing conditions are cloud detection, rain detection, wind speed limits, and daylight. The user can also choose to set limits on other parameters including humidity, temperature, etc.

When it detects adverse conditions, the Boltwood Cloud Sensor III will trigger a contact closure (relay) output. When connected to an observatory roof controller such as the MaxDome II system, this will cause the observatory to close. Note that this will not park your telescope or other equipment.

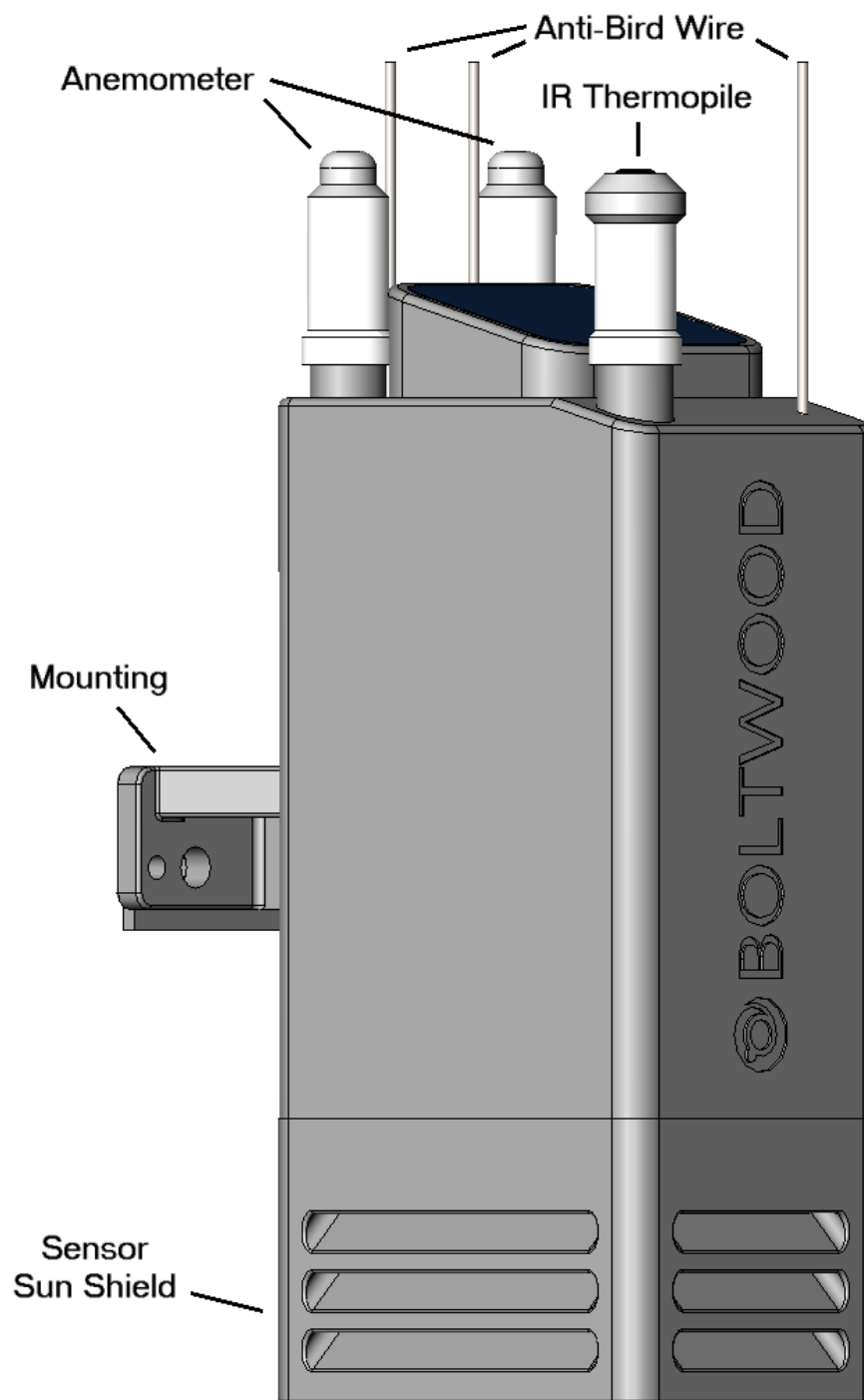
Many users use software to operate the observatory in response to the weather conditions. Diffraction Limited also makes Cyanogen Imaging® MaxIm DL™ software, which includes a flexible observatory shutdown capability. We can also recommend ACP Expert from DC-3 Dreams, which in conjunction with MaxIm DL, provides a completely automated observatory control system.

Boltwood Cloud Sensor III primary communication is via a Wi-Fi connection. It can operate as a Wi-Fi hotspot, or it can connect directly to your wireless network. It provides browser-based status and configuration screens. It also provides ASCOM Alpaca Observing Conditions and Safety Monitor status, which allows direct access to sensor readings by ASCOM-compatible astronomical software packages.

An RS-232 serial interface is also available. When this option is purchased, a serial cable is included with the package. The Wi-Fi transceiver can optionally be disabled permanently at the factory, for radio quiet installations.

The sensor operates from a 10.5V to 24V DC power source, which makes it compatible with 12V solar-charged battery systems. A universal AC adapter and extension cable is also included for locations with available mains power.

A Quick Tour of your Boltwood Cloud Sensor III



The main sensors are located at the top of the unit. The IR Thermopile detects the temperature of the sky by sensing infrared radiation in the 8 to 15 micron wavelength range. It uses a thermopile to do this. This is compared to the measured ambient temperature to calculate the “Sky minus Ambient” reading. A large reading indicates clear skies, as the sensor is exposed directly to the cold of space. If the temperature is nearly the same as ambient, that indicates low clouds and a high probability of precipitation.

Please note that very high cirrus clouds made of ice crystals are by their nature very cold and may in some cases not be detected by the cloud sensor. Fortunately, cirrus clouds do not produce precipitation, so they are not a risk for your equipment.

Weather conditions can exist where rain falls without clouds overhead. An example is a situation where high winds aloft carry precipitation from clouds over an area that is not under cloud cover. For this reason, the Boltwood Cloud Sensor III includes a very sensitive raindrop detector.

The rain sensor can detect individual rain drops. It will not signal a rain condition until a couple of drops are seen in a short period of time, in order to avoid false-triggering because e.g. an insect landed on it.

The Anemometer measures wind speed. It has two sensor stalks that operate in a differential fashion. It works by detecting the temperature drop on the heated stalk caused by blowing wind. The second unheated stalk provides a comparison reference. Sunlight if present will heat both stalks identically, which removes any bias caused by solar heating.

Note that the Thermopile, Anemometer, and Rain sensor stalks are user-replaceable if they should ever become damaged. Contact our technical support for assistance.

The Anti-Bird wires are optional. They keep birds from landing on the sensor. Aside from directly blocking the sensor’s view of the sky, birds tend to leave droppings, which would also block clear access to the sky in a somewhat more permanent fashion. The wires give the bird a gentle poke in the underside, which encourages them to fly off.

We recommend installing the Anti-Bird wires only if the sensor is installed out of reach. Otherwise someone could accidentally poke themselves on them. The sensor should be installed high up for a clear, unobstructed view of the sky and to minimize wind blockage, etc.

The Sun Shield protects the weather sensors underneath from direct sunlight, while allowing air to flow through freely.

Underneath the Sun Shield are power and roof cable connections, plus several additional sensors. Keep this area clear and open to the environment, do not cover it.

The TEMPERATURE sensor measures ambient temperature. It extends down from the sensor body to ensure it is exposed to freely-flowing air.

The HUMIDITY sensor measures relative humidity and dew point.

The DAYLIGHT sensor measures the ambient light conditions underneath the sensor. It will trigger before sunrise. This sensor is more important than it might seem - over the years more than one observatory has accidentally exposed the telescope aperture to direct sunlight, with catastrophic results for the attached instrumentation! You may need to disable this function temporarily if you need to open your observatory in the daytime for maintenance.



Bottom of Cloud Sensor

There are also two INDICATOR LEDS on the bottom of the sensor. The right-hand LED glows when power is present. It illuminates green for safe weather conditions, yellow when light clouds are present, and red for unsafe weather conditions.

The left-hand LED shows Wi-Fi communications link status. It glows amber when a link is active, and blinks green with a successful message transfer, and red for a failed message transfer (note that an occasional red is normal depending on Wi-Fi signal strength).

The serial port interface is to the right of the Boltwood logo; the serial cable is an optional extra. Please refer to Section 6 for more information.

2 – Supplied components

Observe proper handling procedures for sensitive electronic equipment and unpack your Boltwood Cloud Sensor III carefully in a clean, dry, static-free area. Inspect the contents to ensure all components are present and in good order. You should find the following:

- Boltwood Cloud Sensor III unit
- U-bolt mounting bracket for 1" (25 mm) diameter pole
- U-bolt backing plate
- Quick Mount Bracket
- Anti-Bird wires (3 + 1 spare)
- Universal AC power supply, 100 – 250VAC input, 12VDC 1A output
- DC extension cable, 50 feet (15 m)
- Quantity 4 – black UV resistant cable ties
- Quantity 4 – #6 Phillips Pan Head screws
- Sensor Reset Magnet tool
- Flash Drive

Serial port option (-S and -SO) versions only also include:

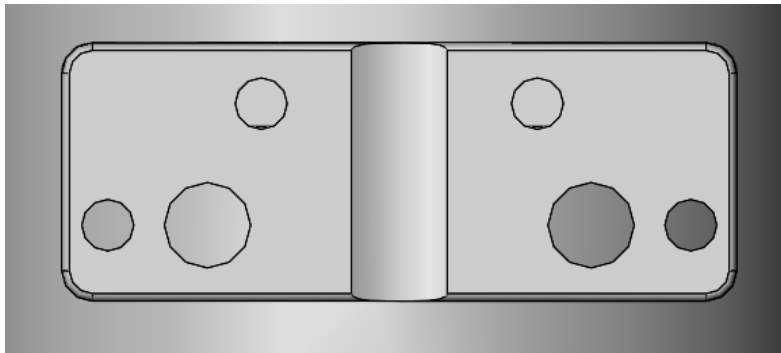
- 50 foot (15 m) RS-232 serial cable with DB-9 connector

3 – Equipment Installation

The Boltwood Cloud Sensor III must have a clear view of the sky overhead, and unobstructed air flow. It can be installed on a pole, fence post, etc. It is also possible to install it on a roof fascia, although you should avoid installing over a potentially hot surface such as concrete or in any situation that blocks wind flow. We recommend installing it high enough that it is not easily accessed by wandering humans, especially if the anti-bird wires are installed.

The sensor head can be mounted several different ways:

Direct Mounting

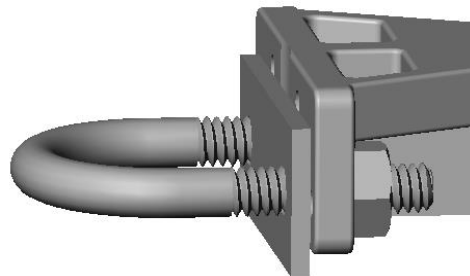


The sensor head can be directly bolted to a flat object. There are four 0.17" (4.3 mm) holes, with pairs available at 0.9" (22.9 mm) and 1.9" (48.3 mm) spacings. These holes will accommodate a #6 or M4 bolt.

There are also two 1/4" (6.4 mm) holes on a 1" spacing (25.4 mm), which will accommodate 1/4" or M5 bolts.

Pole Mounting

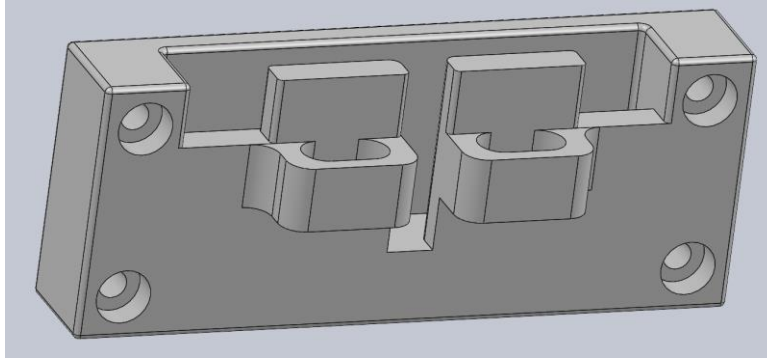
The sensor is supplied with a 1" (25.4 mm) pole mount U-bolt and backing plate. Simply arrange the U-bolt over an appropriately sized mounting pole. Install the supplied backing plate and then the cloud sensor, then attach the supplied nuts. The backing plate will help prevent flexure of the cloud sensor mounting, but be careful not to overtighten as this could damage the sensor.



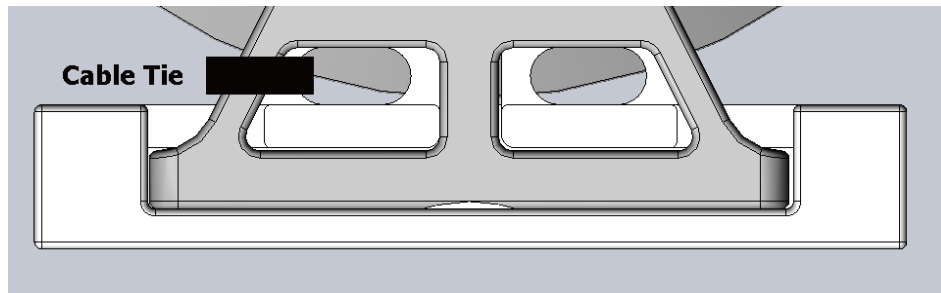
Quick Mount Bracket

The Quick Mount Bracket is handy for quickly attaching the sensor head to a fence post, roof fascia, or other convenient mounting point.

Using the supplied Phillips head screws, simply screw the bracket onto your mounting surface and then slide the sensor's mounting bracket over top.



If needed, the sensor can be quickly installed and removed by just sliding it on and off. For most installations you will want to ensure that the sensor is anchored down. Run a cable tie (supplied) through the sensor mount and the Quick Mount Bracket anchor loop, as shown below.



Power Connection

A universal AC power adapter is included. Please note that it is not rated for outdoor installation. We recommend you install it inside your observatory, warm room, or other building.

The included extension cable has an industry-standard 2.5 mm Inner Diameter / 5.5 mm Outer Diameter power barrel connector plug, which plugs into the bottom of the cloud sensor. Be sure to tie off the cable with the supplied cable tie so it does not get pulled out of the sensor. The cable should extend below the sensor for a few inches before it is tied off.

If the AC power supply is not being used, connect the cloud sensor to a 12V power source. Although nominally a 12V input, it will accommodate a voltage range of 10.5V to 24V. The polarity of the connector is not important – it can be connected either way.



View of Connectors

Roof Close Cable

If a Roof Close Cable (not included) is to be connected, it plugs into the ROOF connector at the bottom of the sensor head. It requires an industry standard 1.3 mm ID / 3.5 mm OD power barrel connector plug (example: DigiKey EP505B-ND). An isolated electromechanical relay provides a contact closure whenever unsafe conditions are detected. The cable should be tied off a few inches below the sensor, to avoid any risk of it being pulled out of the sensor.

The contact will also close if power is lost to the cloud sensor, which is useful for shutting down the observatory in the event of a power loss. This assumes your roof system has a battery backup.

4 – Initial Network Setup

Please see Section 6 for instructions on connecting the serial port version.

The cloud sensor can be accessed and operated in a number of different ways, as detailed in Chapter 5. However, common to any method you wind up choosing is the requirement to establish a wireless connection to the device in order to view the environmental data and to set up the monitoring parameters. The most basic way is to access the sensor directly via its Access Point using a smartphone or computer with a web browser, regardless of the operating system your device uses. This allows the initial connection to the sensor and setting up of a Wi-Fi link to your observatory network and is described in this chapter.

Alternatively, if you are using a Windows-based device, we also offer (and recommend) the use of the Clarity III application. It provides access to the same setup and viewing screens described here but also offers additional capabilities and shortcuts. Installation and operation of Clarity III is covered in Chapter 5, along with ASCOM connectivity options.

Discussion on passwords

A number of passwords are used when installing and operating the cloud sensor. To avoid confusion, these are:

1. Your observatory network's Wi-Fi SSID and Password (network security key). If you installed the network, this is for your existing observatory router/access point. If this is at a professional site, get this from your network administrator or IT department.
2. The sensor's *Access Point* has an *SSID* of BCSIII and a *Password* (network security key) that is the unit's serial number, in the format BCS312345678. The sensor's serial number is printed on the label affixed to the unit under the mounting bracket.
3. The cloud sensor's web view also has a *Settings Password*, which is disabled by default but which you can set up in the *About* page. If you are a single user on your own network, you do not really need to set this password. For security reasons, a password is **highly recommended** if the sensor is available publicly or to a group of local users.

This password restricts:

- Ability to update the firmware
- Ability to change the conditions under which the observatory closes down
- Ability to change the thresholds for observing conditions

This password does NOT restrict:

- Accessing any of the screens

- Viewing the cloud sensor information
- Changing the conditions that cause your computer to sound an alarm - the settings are specific to your browser and affect only you. Do not use private browsing because will lose all Alert settings when you close the browser and you'll always go back to defaults if you reload the page.

Note: Should you lose your password, you can reset it using the Master Reset procedure provided further on in this chapter.

Cloud Sensor ID and Default Setup Password

We strongly recommend when you initially configure your cloud sensor's network access, that you do so in a comfortable indoor environment with very strong Wi-Fi signal strength. This will make it easier to confirm everything is operational before mounting the sensor outdoors.

When the sensor is powered up, the unit acts like a network access point and identifies itself so that you can connect to and configure it. This identification includes the name of the unit which is BCSIII and which is also the Access Point's SSID, displayed when connected to your Wi-Fi network.

The unit's default Setup password is also the sensor's serial number. It will be in the format BCS312345678.

We highly recommend changing to a strong password for security reasons.

Note: Should you lose your password, you can reset it using the [Master Reset](#) procedure provided further on.

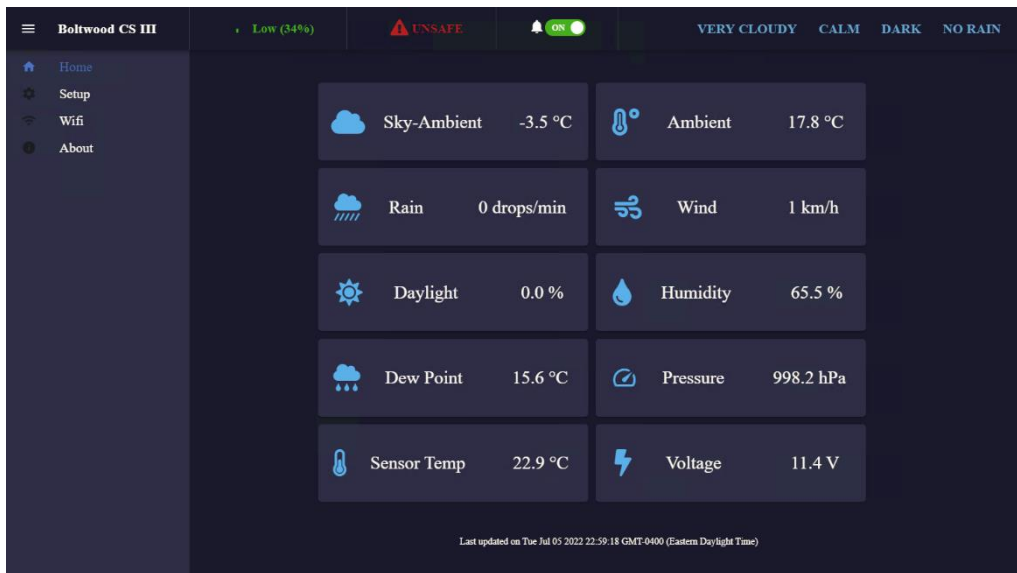
Access Point connection

When the Boltwood Cloud Sensor III is powered up for the first time, it will default to its Access Point mode. The Access Point is actually a hot spot and can be accessed from a smartphone or notebook computer.

Note: If you use an iPhone to configure the sensor via its Wi-Fi Access Point, it may require temporarily disabling its "Auto-Join" setting for your Wi-Fi network. Otherwise when it finds that your cloud sensor's access point has no Internet access, it will automatically switch back to talking to your network.

Connect to the sensor as follows:

1. Go to your network connections and search for networks – the sensor will use BCSIII as its SSID (Network ID). Connect to that network. The unit's Password (network security key) is its serial number. It will be in the format BCS312345678. Note that this hot spot remains active even when the sensor is connected to your Wi-Fi network.
2. Open your web browser and enter the sensor's default IP address of 192.168.4.1. This brings up the sensor's Home web page. Current sensor readings are displayed on this page, as well as menu items in the left hand margin to access additional pages.



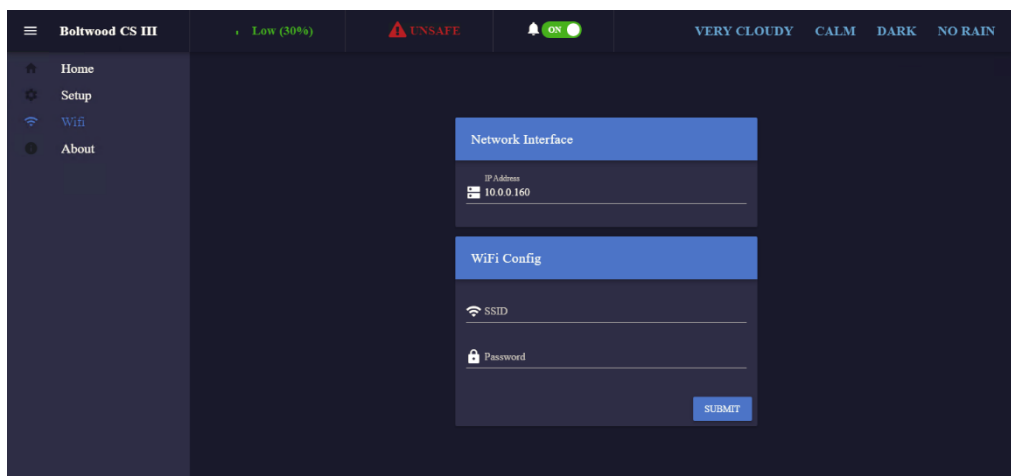
Any browser-based device connecting directly to the Access Point will be able to see the weather conditions information.

Wireless network connection

While you can operate the sensor from its Access Point as described above, most users will want to connect it to their observatory's Wi-Fi network. The sensor always operates in both Access Point and Wi-Fi Network modes simultaneously.

Use the following procedure to set up a connection to your Wi-Fi network.

1. On the Home web page, click on the *Wi-Fi* menu item. This brings up the Wi-Fi configuration page for your network information.



2. Click *SSID* and then *Password* fields and enter the information for your observatory network. The sensor will immediately look for your network and connect to it. This will take a few seconds. Once successfully connected, any client devices on the observatory network will be able to access the unit. The sensor will identify itself on the network using:

```
<serialnumber>.local
```

For example, if the serial number is BCS312345678, the sensor appears at:

```
http://BCS312345678.local
```

NOTE: The Access Point mode always remains functional, so if there is something incorrect with the *SSID* or *Password* you entered for your network, you will be able to try again.

The sensor will continuously try to reconnect if the network ever goes down. This ensures the sensor will come back up in the event of a network outage.

Network Identification

The cloud sensor will identify itself on your observatory network as follows:

```
<serialnumber>.local
```

When installed, the Clarity III software will automatically search for your cloud sensor and identify its IP address, if needed.

In Windows, another way to identify your sensor's IP address is to type the following into the Command Prompt:

```
tracert <serialnumber>.local
```

This command can also be used in the terminal mode of Linux if the `tracert` command is installed. In the Macintosh operating system, the same feature is available via the *Network Utility/Traceroute* tab.

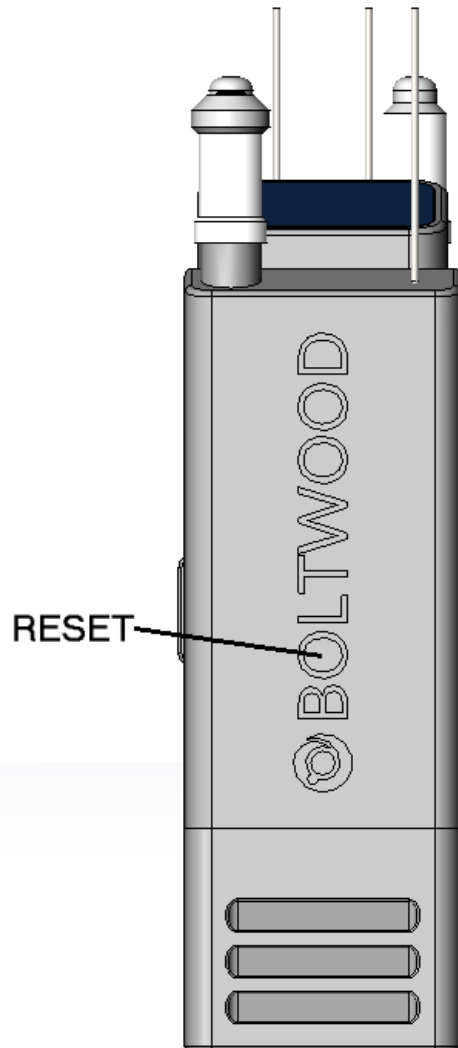
Master Reset

If you have specified a *Settings Password* on the About page, then you cannot edit the alert thresholds or roof close/unsafe options unless you first enter that password. You also need that password to upload firmware on the About page.

If you lose your *Settings Password* or have network connection problems, it is possible to reset the unit to the factory default settings using a magnet.

To perform a reset, proceed as follows:

1. Look at the sensor from the front (the side opposite the mounting bracket). You will see the Boltwood logo. There is a hidden magnetic reset switch inside the housing directly behind the first letter "O".



2. With power applied, wave the "O" on the supplied Sensor Reset Magnet tool over top of the "O" on the sensor. The unit will reset **all** settings to factory defaults. In addition:
 - The Wi-Fi network access will be turned off.
 - The password used to access the threshold and alert settings and to upload firmware will be disabled, i.e. no password
 - The Access Point function will be in the default mode, i.e. the access point will have a SSID of BCSIII and password will be the serial number in the format BCS312345678.

Sharing Your Sensor – Ports and Security

We recommend that no more than five connections be made to the Boltwood Cloud Sensor III at a time. Beyond this the sensor may reject additional connections, to prevent excessive processor load.

If you plan to expose your Boltwood Cloud Sensor III outside your local network, there are some security issues to consider.

First and foremost, be sure to configure a strong Setup password. This will prevent someone from changing the protection thresholds for your observatory, which could either prevent your observatory from operating or risk subjecting it to damaging conditions. A strong password will also prevent someone from potentially uploading a malicious firmware image into your device via the firmware update feature.

The following Wi-Fi Ethernet ports are used by the sensor:

- Port 80 – Web View and Alpaca REST server
- Port 88 – Network Configuration Web Page
- Port 32227 – Alpaca Discovery

To share basic functionality outside your local network, you will need to expose Port 80 through your firewall.

If you want to use Alpaca functionality through the firewall, it will also be helpful to expose the 32227 Alpaca Discovery port. This is not mandatory if you are willing to manually set up the address for the sensor.

We recommend that you do not expose Port 88. This port is used only for setting the network ID and password on initial setup. This should not be exposed as it could potentially allow someone to disable the sensor's network connection or possibly even connect the sensor to some other wireless network.

If you are not planning to use the Access Point feature, we strongly recommend turning it off. This will prevent an unwelcome visitor from accessing the sensor directly from a mobile device. If you are connected to a Wi-Fi network you normally would not need the Access Point.

5 – Software Installation and Operation

You have several options available to connect to and operate the unit. These are:

- The Clarity III application
- A web browser (initial connection procedure is described in [Chapter 4](#))
- Observatory control programs that support ASCOM Alpaca

These options are described below.

Clarity III

We strongly recommend always operating the Boltwood Cloud Sensor using the Clarity III software if a suitable computer is available on your network. Unlike a basic connection using just a web browser, Clarity III can provide continuous logging of your weather data in addition to technical data on the performance of the sensor.

Clarity III is currently supported on Windows 7 and higher and is included on the supplied Flash Drive at:

`\Boltwood Cloud Sensor III\SetupClarityIII_x64.exe`

It can also be downloaded from <https://diffractionlimited.com> – please see the Boltwood Cloud Sensor III product page, Downloads tab.

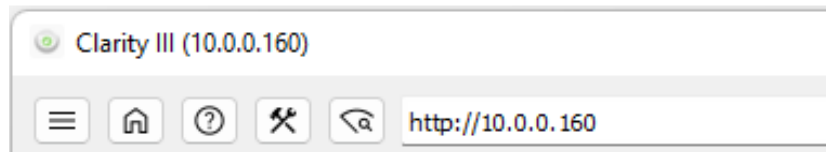
To install the program, run the installer file and follow the onscreen instructions.

Note that the main window of Clarity III is actually a web browser. Normally it is set to look at your BCSIII's Home page. If you access the cloud sensor with just a web browser, then you will see the same thing, but without the Clarity III menu bar.

Clarity III performs several specific functions:

- Helps you identify your cloud sensor on the network
- Logs sensor measurements to disk
- Provides monitoring and control via a web view (this same web view can be accessed through a web browser)

At the top left of the Clarity III application main window are several quick access buttons.

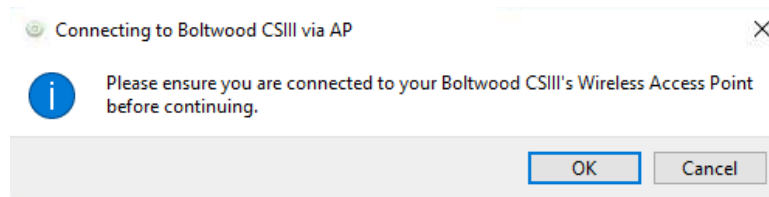


From left to right, the buttons are:

- *Menu*: Provides access to Clarity III's features via a dropdown menu.
- *Home*: This function is set up using the *Discover Boltwoods* feature. It shows all Boltwood sensors on the network. If you have more than one, click on the one you want and then click the *Set Home* button.
- *Help*: Opens this user manual.
- *Connect to Access Point*: Connects your observatory network to the sensor's Access Point and is only used for the initial connection. It prompts the user to connect to the Access Point and then goes to 192.168.4.1:88 in the address field.
- *Discover Boltwoods*: This function only works once you are connected via Wi-Fi and is used to find multiple Boltwood sensors on your network.

Using the Access Point to set up the cloud sensor with Clarity III

1. On your observatory network computer, switch from your regular Wi-Fi network and connect to the BCSIII access point. This is usually done through Windows Network and Internet Settings. Disconnect from your observatory network and search for the BCSIII network, and connect to it.
2. Start Clarity III and click the *Connect to Access Point* button. A pop-up window will appear:



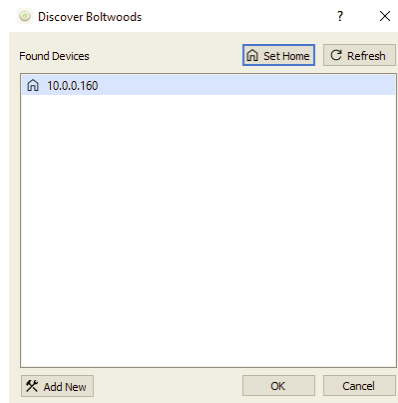
Click *OK* and follow the instructions.

3. Enter your observatory network's *SSID* and *Password* in the two fields and click *Submit*.

SSID

Password

4. Disconnect your PC from the Boltwood access point, and reconnect your PC to the regular observatory Wi-Fi network. Click the *Discover Boltwoods* button. A list of available cloud sensors appears, in this



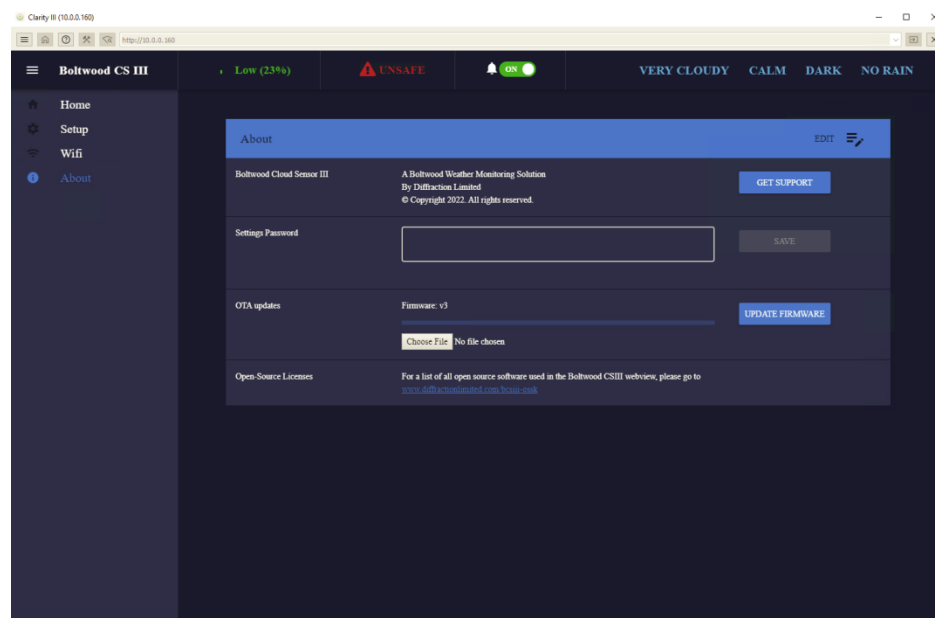
example 10.0.0.160.

5. Click on the found device. If you have multiple cloud sensors then select the one you want and click the *Set Home* button to make this the home page in Clarity III. Click OK.

Note: To configure a different sensor later on, repeat steps 1 to 5 and select the desired sensor.

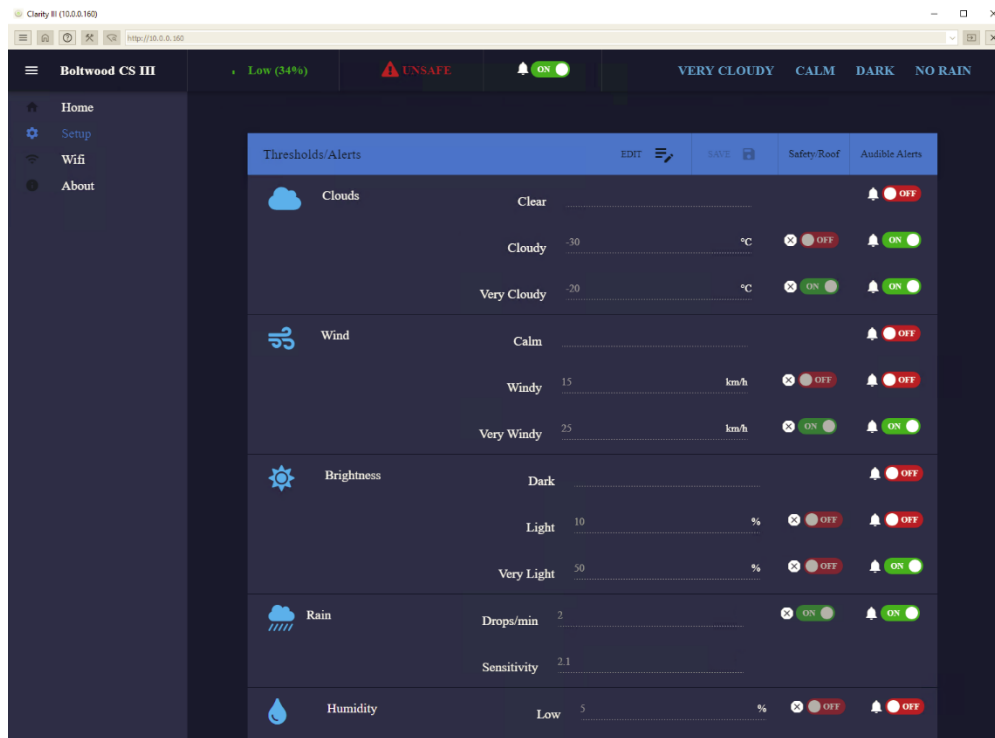
6. To configure an optional *Settings Password* click the *About* menu item to access the About page.

Note: By default, this password is not set. If you are a single user on your own network, you do not really need to set this. For security reasons, a secure password is highly recommended if you intend to



access the sensor interface publicly or if it is made available to a group of local users.

7. Click the *Edit* icon on the right side of the blue bar on the About page. When clicked, it enables you to make changes on this page. If you previously set a password then you will be prompted for it before you are allowed to make any changes.
8. Specify a secure password in the *Settings Password* field and click *SAVE*.
9. Click the *Setup* menu item to access the Setup page.



This page allows you to set the thresholds for detecting unsafe environmental conditions and to enable or disable audible alarms.

10. To edit a threshold parameter or roof close options you must first click the *Edit* icon near the centre of the blue bar on the Setup page. Those values are stored in the cloud sensor itself and changing them affects all users. If a *Settings Password* has been set, you will first be prompted for that password when you click *Edit*.
11. Click the item you want to change and type in the desired value. Change any additional parameters you want to. When you are done, click the *Save* icon to the right of the *Edit* icon.

Note: Use the default threshold values as a starting point and make any necessary adjustments specific to your observatory site's environmental conditions.

With a new sensor under typical conditions, the settings for Cloudy at -35° C and Very Cloudy at -20° C are typical. However this may vary a bit with the seasons. Over a long period of time the thermopile window may get etched depending on your environmental conditions - wet/pollution/salty spray conditions do more damage, high desert does less, and so the "Clear" condition may result in a smaller Sky-Ambient reading.

Regarding the Rain sensor settings, if you get false counts at times, then increase the Sensitivity number slightly. We recommend 2.3 as a starting point. The Drops/min setting should usually be set to 2. If it is set at 1, then an insect landing on the sensor might trigger a shutdown. If you get 2 drops in a minute, then it is probably raining.

In some tropical locations like Florida or the Caribbean, a user might want to shut down at a high humidity level since high humidity can cause equipment problems.

Wind speed considerations can vary greatly with the location and the construction type of the observatory. Set these to reasonable values for your particular situation.

Alerts

You can change any of the audible alert ON/OFF settings at any time without clicking *Edit*. They only affect your specific instance of Clarity III or web browser. They do not affect any other users.

Audible alerts can be used in different ways, depending on how you like to run your observing and imaging sessions. Users often want to be alerted when conditions are either "good" or when they are "unsafe".

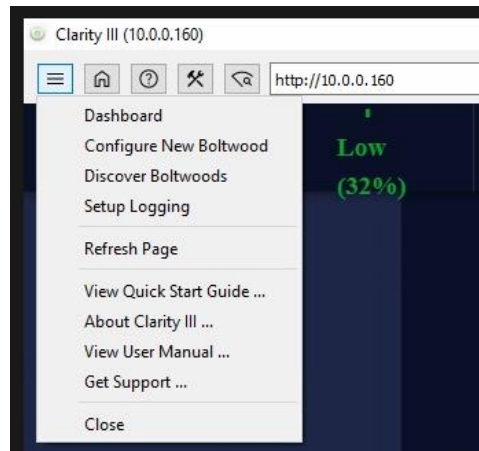
It is not uncommon to switch back and forth between these conditions. A use case example here: It's currently cloudy but the forecast is for clear skies later on. You can turn on the audible alerts to sound when it becomes clear. When it clears, you open your observatory. You should then switch the alerts back to "unsafe" conditions, especially if the observatory will be unattended or is located in a remote area.

Note: A switch that lets you turn off an audible alert off will appear in the upper-right corner of the screen no matter what page you are on whenever an alert sounds.

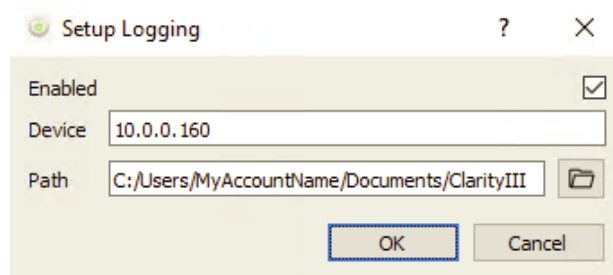
1. To change the roof close options click Safety/Roof item on the blue bar. This enables the text edit fields for the On/Off switches for roof close.
2. When you are done, click the *Save* icon to the right of the *Edit* icon.

Additional Clarity III functions

Clarity III's additional features are accessed via the dropdown menu shown here:



- **Dashboard:** Displays the Home page.
- **Configure New Boltwood:** Connects to the sensor's Access Point to permit configuration. This is the same function as the *Connect to Access Point* button on the quick access bar.
- **Discover Boltwoods:** This function only works once you are connected via Wi-Fi and is used to find multiple Boltwood sensors on your network. It provides the same function as the *Discover Boltwoods* button on the quick access bar.
- **Setup Logging:** Allows you to set up a location for a log file generated by the sensor. That file will contain collected weather data in addition to technical data on the performance of the sensor.



The name of the log file will be based on the current date, in the format YYYY-MM-DD.txt. By default, the file will be saved to Documents\Clarity III. This command lets you change that location.

- **Get Support:** Opens our technical support page at:
<https://diffractionlimited.com/forum>
Refer to Chapter 6 for details.

The remaining items are self-explanatory.

Troubleshooting with Clarity III

In the event of problems with the cloud sensor, it is extremely helpful for us to receive a log of a few days operation of the sensor. Clarity III stores the logs in the folder:

Documents\Clarity III

Right-click on the selected files or folder and select *Send To > Compressed (zipped) folder*. Upload the file to our technical support forum, as explained in the [Technical Support](#) section.

Web Browser

If you are using a smartphone or other non-Windows device, use the device's web browser to connect to the sensor, set up a Wi-Fi connection to your observatory network, view current weather information, configure the sensor's thresholds, and update firmware. Initial network setup using a web browser is described in [Chapter 4](#). Clarity III software is not available as a mobile device app.

The sensor web page views have the same appearance and functionality as those available via the Clarity III software as described above but without the Clarity III menu bar. Operating the sensor via a web browser does **not** provide the data logging capability of the Clarity III software.

Note: If you use an iPhone to configure the sensor via its Wi-Fi Access Point, it may require temporarily disabling its "Auto-Join" setting for your Wi-Fi network. Otherwise when it finds that your cloud sensor's access point has no Internet access, it will automatically switch back to talking to your network.

ASCOM Alpaca

You can operate the sensor using observatory control applications such as MaxIm DL Pro and other third-party programs through its ASCOM Alpaca interfaces. For more information on ASCOM please visit:

<https://ascom-standards.org>

For assistance in setting up Alpaca please visit:

<https://ascom-standards.org/Help/Platform/html/e3870a2f-582a-4ab4-b37f-e9b1c37a2030.htm>

The Boltwood Cloud Sensor III provides two interfaces:

- ISafetyMonitor
- IObservingConditions

Note: The ASCOM Platform 6.6 for Windows astronomy programs must be installed to use the Observing Conditions and Safety Monitor.

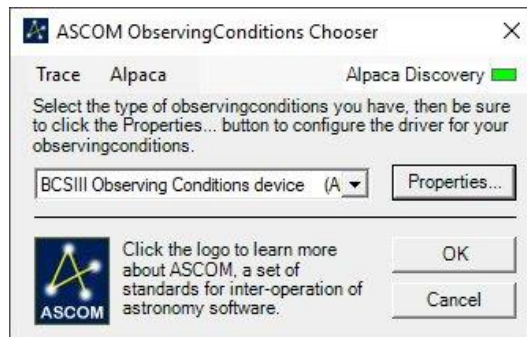
ISafetyMonitor provides a simple Go/No Go indication. If any of the sensor channels are outside the thresholds you have set in the *Setup* screen, the IsSafe property will return False. Otherwise it will return True.

IObservingConditions provides weather information as follows:

- Cloud Cover – this will report 100% when the Very Cloudy threshold is reached, 50% at the Cloudy threshold, and 0% when clear.
- DewPoint – returns the dew point in degrees C.
- Humidity – returns the relative humidity in percent.
- Pressure – returns the barometric pressure in hPa.
- RainRate – this returns 0 if not raining, 10 if raining
- SkyBrightness – returns the approximate ambient brightness level:
0 lux if dark, 10 lux if twilight, 100 lux if bright.
- SkyTemperature – returns the sky temperature in degrees C.
- Temperature – returns the ambient temperature in degrees C.
- WindSpeed – returns the current average wind speed in m/s.

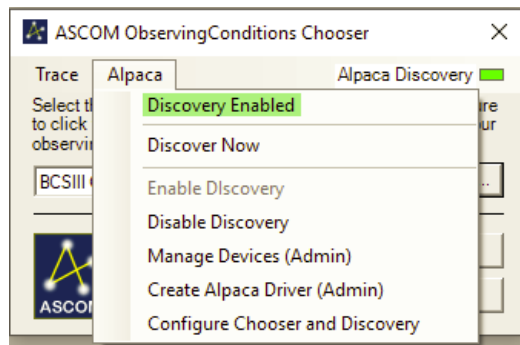
The ASCOM standard provides for some additional measurement options; these are not supported and will throw an exception if accessed.

1. Select the appropriate interface from the dropdown menu and click the *Properties* button.



In most cases, you can use the default settings in the properties window that is displayed and simply need to click OK. This is an ASCOM screen and any functions here are best described by the documentation available on the ASCOM website.

2. When setting up the ASCOM interface for the Safety Monitor, select *Discovery Enabled* under the *Alpaca* menu.



3. Click OK to close the ASCOM Chooser.

MaxIm DL Pro

MaxIm DL Pro Version 6.30 or higher supports the Boltwood Cloud Sensor via the ASCOM Alpaca **Safety Monitor** and **Observing Conditions** features. These are configured from the Observatory Control Setup tab.

Please note that MaxIm DL Pro supports the older Boltwood Cloud Sensor II directly via the older Clarity II software. This option *does not work* with the BCS III. Use the **Safety Monitor** and **Observing Conditions** instead.

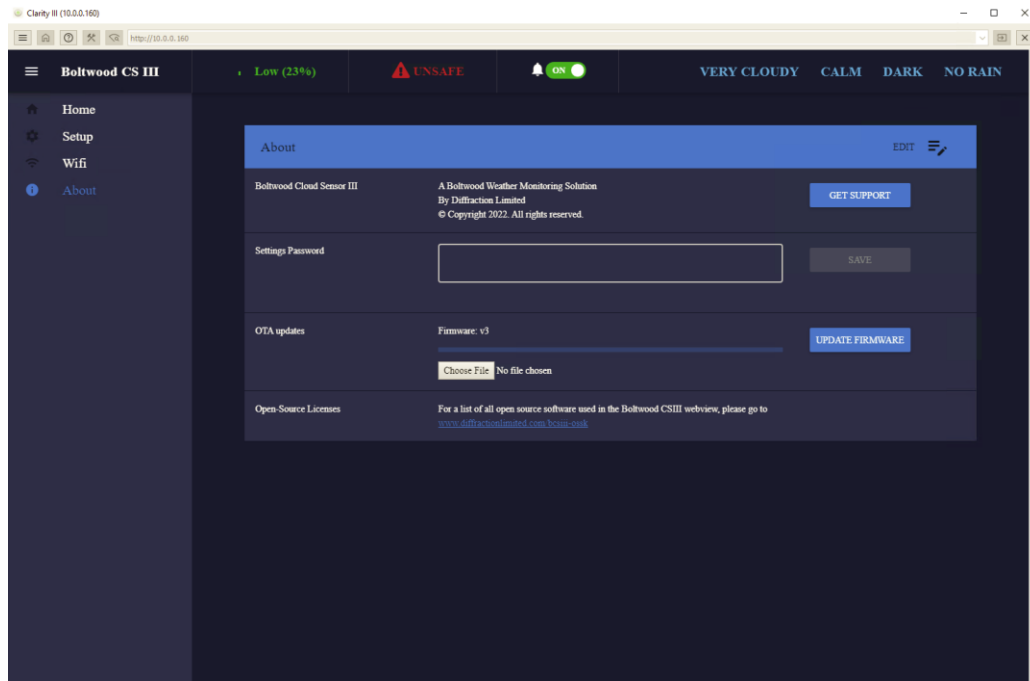
Firmware Update

The sensor's firmware can be updated over-the-air using the web browser interface or the Clarity III software. The update procedure is as follows:

1. Download the firmware file from our web site, and put it on your hard drive. The suffix of the file is .bin, but the prefix name will depend on the firmware version. The file is available from the *Downloads* tab at:

<https://diffractionlimited.com/cloud-sensor/>

2. Select the *About* item on the main menu to open the About page.



3. Click the *Edit* icon at the right side of the blue bar in the *About* display. If a *Settings Password* has been set, you will be prompted for that password.
4. Click the *Choose File* button.
5. Browse to the firmware file on your computer that you downloaded from our web site and then click *OK*.
6. Click the *UPDATE FIRMWARE* button to reprogram the cloud sensor. When the update progress reaches 100% the cloud sensor will reboot.

Do not interrupt the power or internet connection once the procedure has started.

Should a firmware update fail for any reason, there is a way for the user to restore the firmware. Please contact our technical support for assistance. Refer to [Chapter 6](#) for details.

6 – Serial Port Option

This section refers to the -S (serial + Wi-Fi) and -SO (serial only) options.

The -S version operates the same as the standard Wi-Fi version, and supports an extra optional serial interface.

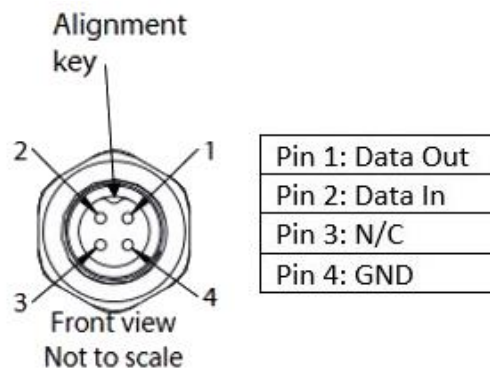
The -SO version is the same as -S, except that the Wi-Fi interface has been permanently disabled on the circuit card. Only the serial interface is available.

Hardware Connection

The serial port version has an extra connector, circled in green in the diagram below. The included 50' cable terminates in a standard DB-9 RS-232 connector.



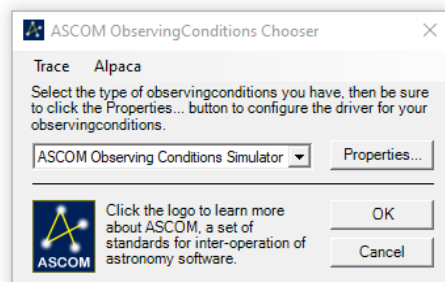
If you wish to make your own cable, the mating connector is Tensility 50-00605. The serial connection is RS-232, at 9600 baud, 8 bits, 1 stop bit, no parity.



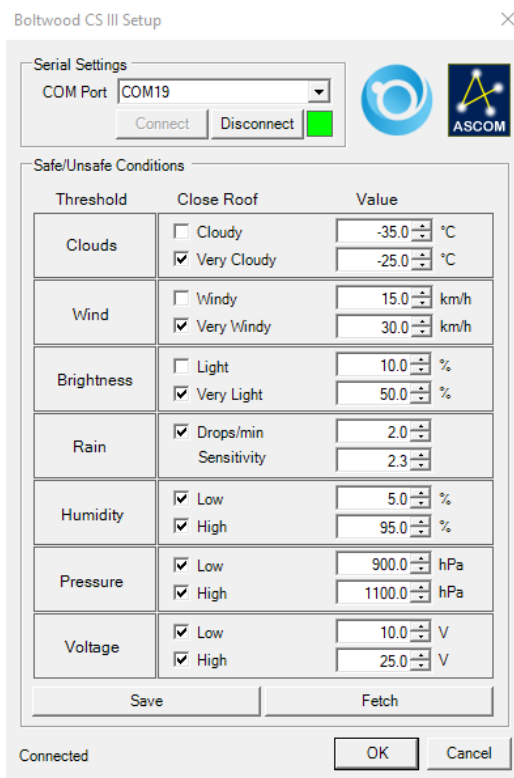
ASCOM Driver

The ASCOM driver works via a windows COM port. The hardware can be a built-in RS-232 port, PCIe serial interface card, or a USB-to-serial converter.

The ASCOM driver implements two interfaces: ObservingConditions and SafetyMonitor. From your observing application software, for example MaxIm DL Pro, you can access the ASCOM Chooser to access one or both interfaces.



First use the ASCOM Chooser to select the Boltwood Cloud Sensor. Then click the Properties... button.



You will need to select the COM port that has been allocated to the cloud sensor. Click Connect to establish the connection. This will verify that the port selection is correct and allow you to adjust the Cloud Sensor settings.

The Safe/Unsafe Conditions section has the same options as the Wi-Fi version Settings page, except of course audible alerts are not available. For each of the conditions being monitored, you can determine at what level they cause “Unsafe” conditions to be reported.

When you click the Save button, the settings will be transmitted to the cloud sensor. You can also fetch the current settings by clicking the Fetch button.

When all settings have been made to your satisfaction, click the OK button to save the COM Port selection.

Serial Protocol

Most users will operate the Boltwood Cloud Sensor III serial version via the supplied ASCOM driver. Users may in some cases wish to communicate directly via custom software; for example, if they are using a non-Windows platform and/or custom software. This section describes the serial protocol used.

The serial protocol is based on the ASCOM Alpaca interface definition.

Note: The protocol includes all ASCOM-standard parameters, including that some that are *not* supported by the Boltwood Cloud Sensor III. This will allow this same serial protocol to be used by other devices in the future.

The RS-232 connection is 9600 baud, 8 bit, 1 stop bit, no parity.

Each communication starts with a Request Message from the controlling computer, and the cloud sensor responds with a corresponding Response Message. Available messages are:

- Request Data
 - Request data for any parameter specified in the ASCOM ObservingConditions or SafetyMonitor standard
- Fetch All
 - Returns *all* of the ASCOM parameters for ASCOM ObservingConditions or SafetyMonitor in one message
- Read or Write Thresholds
 - Read the current threshold settings from the cloud sensor (See the description of the Wi-Fi based Setup page above for an explanation of each parameter)
 - Write new threshold settings to the cloud sensor

All parameters are separated by spaces, and each line is terminated by a linefeed character, denoted <LF>.

Request Data

Request Message:

G OC|SM V<LF>

Parameters:

G G for GET

OC|SM OC for ObservingConditions or SM for SafetyMonitor

V Value to query based on ASCOM standard interface definitions:

0 or 1	0 = Unsafe, 1 = Safe
averageperiod	Not currently supported – returns NA
cloudcover	0 = Clear, 50 = Cloudy, 100 = Very Cloudy, %
dewpoint	Dewpoint in degrees C
humidity	Relative humidity in %
pressure	Pressure in hPa
rainrate	Rain rate in mm/hour
skybrightness	Sky brightness in lux
skyquality	Not currently supported – returns NA
skytemperature	Sky temperature in degrees C
starfwhm	Not currently supported – returns NA
temperature	Ambient temperature in degrees C
winddirection	Not currently supported – returns NA
windgust	Peak wind speed in last 2 minutes, m/s
windspeed	Current wind speed, m/s

<LF> Linefeed character

Response Message:

0|1|2 R<LF>

Parameters:

0|1|2 Status code:

0 = success

1 = client error

2 = server error

R Response to GET request, or a message describing the error
<LF> Linefeed character

Examples:

Request: G OC skytemperature<LF>

Response: 0 20.0<LF>

Request: P OC connected 2<LF>

Response: 1 Invalid parameter: Connected expects 0 or 1<LF>

Request: P OC connected 1<LF>

Response: 0<LF>

Fetch All

Request Message:

G OC|SM all<LF>

Parameters:

G	G for GET
OC SM	OC for ObservingConditions or SM for SafetyMonitor
All	Request all parameters
<LF>	Linefeed character

Response Message:

0|1|2 R<LF>

Parameters:

0|1|2 Status code:

0 = success
1 = client error
2 = server error

R Response to GET request, or a message describing the error.
Responses as follows:

ObservingConditions (see definitions above):

averageperiod cloudcover dewpoint humidity
pressure rainrate skybrightness skyquality
skytemperature starfwhm temperature winddirection
windgust windspeed

SafetyMonitor:

0 Unsafe
1 Safe

<LF> Linefeed character

- Where parameters are strings, supported values are encoded by their specified type, and unsupported parameters return NA.
- retcode is 0 or 1 depending on error state of the query, and message is a human-readable error message if retcode is non-zero.

ObservingConditions Examples:

Request: G OC all<LF>

Response: 0 0 0 16.43 42.21 998.08 0 0 NA 27.37 NA 27.77 NA
NA 0.15<LF>

SafetyMonitor Examples:

Request: G SM all<LF>

Response: 0 0<LF>

Thresholds

Request Message:

G|P OC <thresholds><LF>

Parameters:

G|P G for GET or P for PUT
OC OC for ObservingConditions
<thresholds> PUT messages only – list of threshold values (see below)
<LF> Linefeed character

Response Message:

0|1|2 R<LF>

Parameters:

0|1|2 Status code:
0 = success
1 = client error
2 = server error

R list of threshold values (see below), or a message describing the error.

<LF> Linefeed character

ThresholdValues:

Threshold values are listed in this order:

clearcloudy	Sky–Ambient threshold Cloudy, C
cloudyverycloudy	Sky–Ambient threshold Very Cloudy, C
calmwindy	Windy threshold, m/s
windyverywindy	Very windy threshold, m/s
darklight	Light threshold, lux
lightverylight	Very light threshold, lux
rainsensitivity	Rain sensitivity, typically 2.0 to 2.5
raindpmthreshold	Raining threshold, drops per minute
humiditylow	Humidity low threshold, %
humidityhigh	Humidity high threshold, %

pressurelow	Pressure low threshold, hPa
pressurehigh	Pressure high threshold, hPa
voltagegelow	Input voltage low threshold, V
voltagehigh	Input voltage high threshold, V
clearcloudyroof	0 – ignore, 1 – close when Cloudy
cloudyverycloudyroof	0 – ignore, 1 – close when Very Cloudy
calmwindyroof	0 – ignore, 1 – close when Windy
windyverywindyroof	0 – ignore, 1 – close when Very Windy
darklightroof	0 – ignore, 1 – close when Light
lightverylightroof	0 – ignore, 1 – close when Very Light
humiditylowroof	0 – ignore, 1 – close when Humidity Low
humidityhighroof	0 – ignore, 1 – close when Humidity High
pressurelowroof	0 – ignore, 1 – close when Pressure Low
pressurehighroof	0 – ignore, 1 – close when Pressure High
voltagegelowroof	0 – ignore, 1 – close when Voltage Low
voltagehighroof	0 – ignore, 1 – close when Voltage High

Get Thresholds Example:

Request: G OC thresholds<LF>

Response: 0 -35 -25 15 30 10 50 2.3 2 5 95 900 1100 10 25 0 1
0 1 0 1 0 1 0 1 0 1<LF>

Put Thresholds Examples:

Request: P OC thresholds -35 -25 15 30 10 50 2.3 2 5 95 900
1100 10 25 0 1 0 1 0 1 0 1 0 1 0 1<LF>

Response: 0<LF>

Request: P OC thresholds SomethingUnexpected<LF>

Response: 1 Error parsing thresholds<LF>

7 – Technical Support

Technical support for the Boltwood Cloud Sensor III is provided through our support forum at:

<https://diffractionlimited.com/forum>

Click the **Log in** or **Sign up** button at top right. If you have not created an account already, you will be prompted to do so. Otherwise log in with your username and password.

Next, click on **Observatory - Boltwood and MaxDome Systems**, followed by **Boltwood Cloud Sensors**. You will be able to see conversations with other users, which may be helpful to review.

To post a support ticket, click the big red **Post New Thread** button at top right. Give it an informative title, and describe your issue.

In most cases we will request a log file for your sensor. This will allow us to diagnose the issue remotely. In many cases there will be a simple solution to the problem.

Please see the [Clarity III](#) section in Chapter 5, for information on how to run the logging software and collect log data.

8 – Specifications

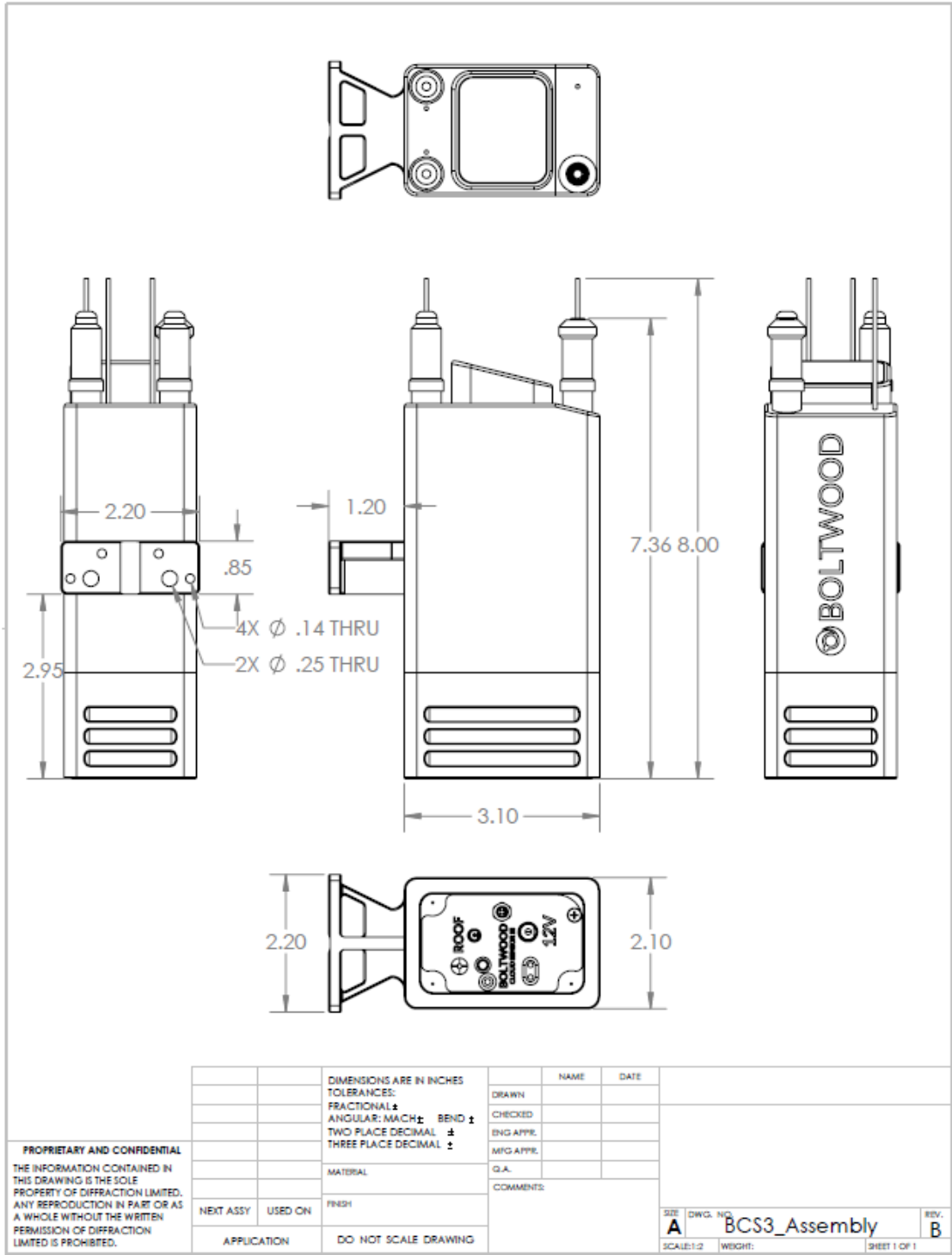
Approximate dimensions	Body 7.5" tall x 4" diameter (190 mm x 100 mm) Optional Anti-Bird Wires add 1" (25 mm) Mounting Bracket 2.5" from center axis (65 mm)
Environmental	-40° C to +55° C Ambient Temperature, all weather. Avoid corrosive environments such as salt spray.
DC input power	10.5VDC to 24VDC, 1A Maximum. Typical power consumption is approximately 2 Watts.
AC adapter	100VAC to 250VAC, 50/60 Hz
Power connector	Barrel style, 2.5 mm ID, 5.5 mm OD, unpolarized Example: DigiKey CP3-1001-ND
Roof Close connector	Barrel style, 1.3 mm ID, 3.5 mm OD, unpolarized Example: DigiKey EP505B-ND
Roof Close circuit rating	12V, 1A
Serial Connector	Tensility 50-00605 (serial option only)
Wi-Fi communications	IEEE802.11b/g/n
Center frequency range	2412 ~ 2484 MHz
Country Policy	Automatic configuration based on network station
Wi-Fi Ports	80 – Web View and Alpaca REST interface 88 – Wireless Setup Page 32227 – Alpaca Discovery

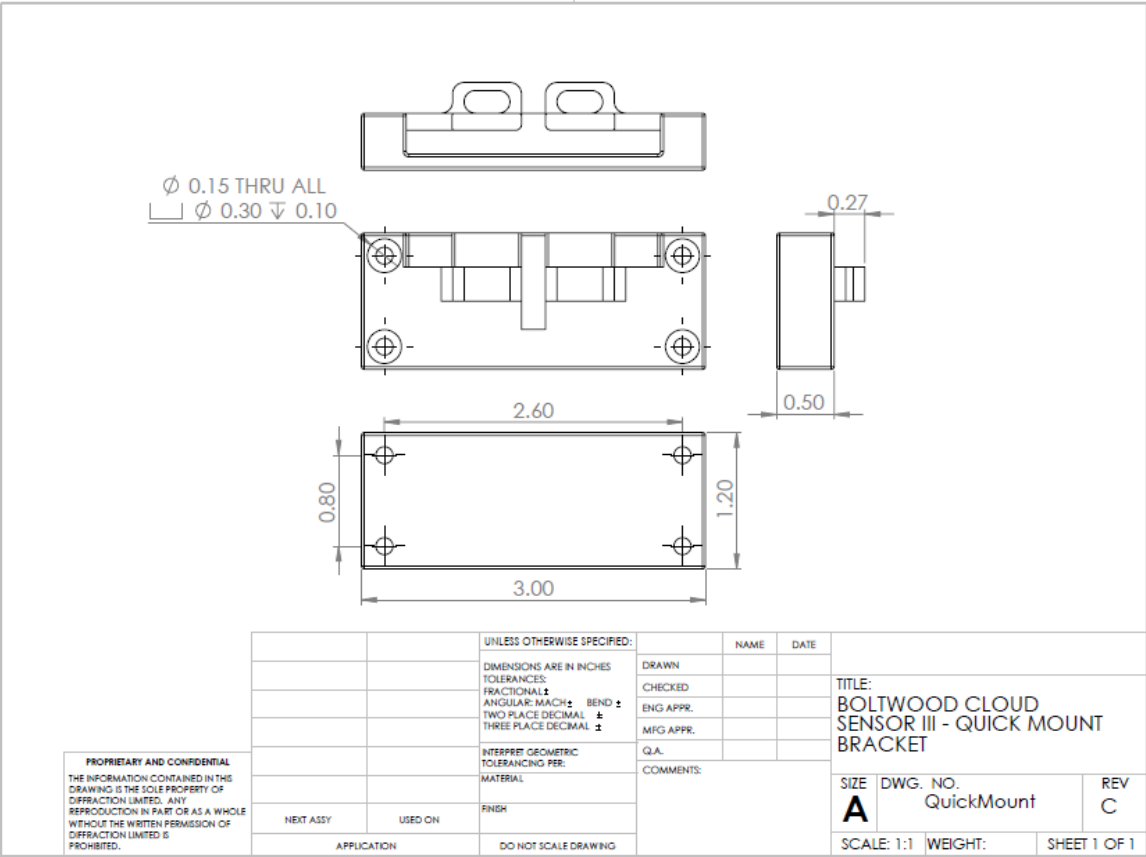
The power connector is unpolarized – the center contact may be either positive or negative.

The Roof Close connector is an isolated contact closure. It may be connected in either polarity. Open indicates safe conditions; closed indicates unsafe. Contacts will close if power is lost. This connection is directly compatible with most observatory roof control systems, including MaxDome II.

The pinout for the optional serial interface connector is described in Section 6.

9 – Mechanical Illustrations







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