



DIFFRACTION LIMITED

***Boltwood Cloud
Sensor III***

User's Manual

Version 0.07 – March 30, 2022

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Industry Canada Compliance Statement

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

European Union

This product has been tested and found to comply with the limits for Class A Information Technology Equipment according to CISPR 22/European Standard EN 55022. Warning: This equipment is compliant with Class A of CISPR 32. In a residential environment this equipment may cause radio interference.

Visit us at:

<http://diffractionlimited.com>

and

<http://forum.diffractionlimited.com/>

Diffraction Limited

59 Grenfell Crescent, Unit B, Ottawa, ON Canada, K2G 0G3

Telephone: 613-225-2732

Fax: 613-225-9688

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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 the behind and fly away. We recommend they be installed only if the sensor is mounted out of reach.

INSTALL AND OPERATE ACCORDING TO THE INSTRUCTIONS. Please note that 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.

NOTE:

There is no compatibility with prior versions of the Boltwood 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

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.

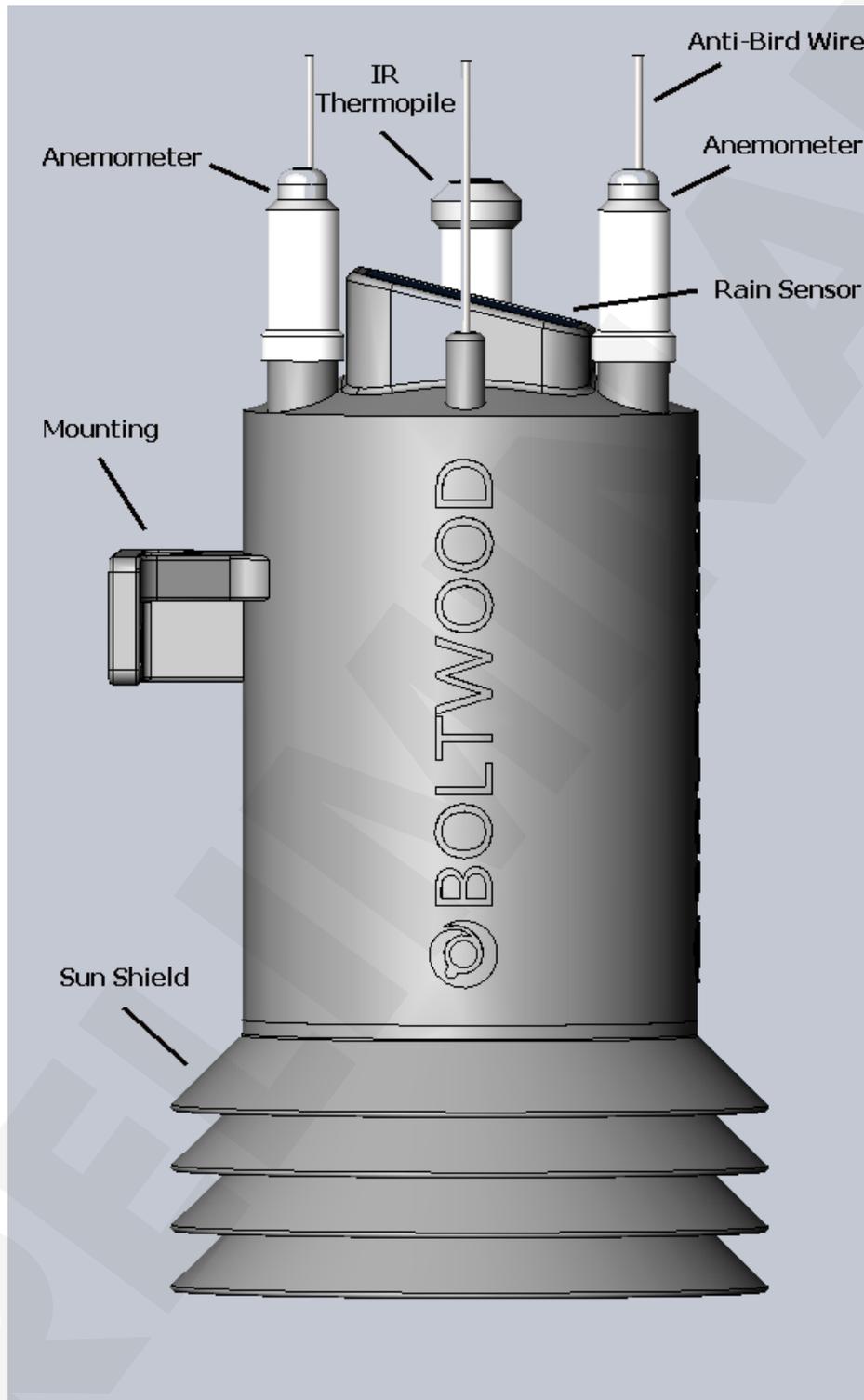
When it detects adverse conditions, the Boltwood Cloud Sensor III will trigger a contact closure (relay) output. When connected to an observatory roof controller such as the MaxDome II system, this will cause the observatory to close. Note that this will not park your telescope or other equipment.

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 communicates via a WiFi connection. It can operate as a WiFi hotspot, or it can connect directly to your wireless network. It provides browser-based status and configuration screens. It also provides ASCOM Alpaca IObservingConditions and ISafetyMonitor interfaces, which allows direct access to sensor readings by ASCOM-compatible astronomical software packages.

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. Typically, a temperature difference of 20°C or more indicates clear conditions. 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 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.

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, they also tend to leave droppings behind, which would also block the view 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.

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 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 (an occasional red is normal depending on WiFi signal strength).

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:

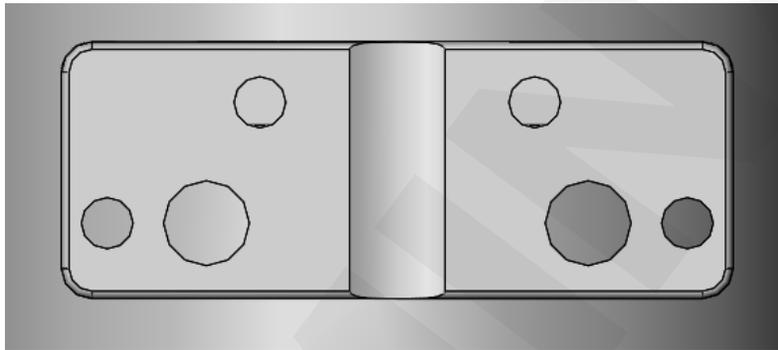
- Boltwood Cloud Sensor III unit
- U-bolt mounting bracket for 1" / 25 mm diameter pole
- Quick Mount Bracket
- Anti-Bird wires (3 + 1 spare)
- Universal AC power supply, 100 – 250VAC input, 12VDC 1A output
- DC extension cable, 50 feet (15 m)
- Qty 4 – black UV resistant zip ties
- Qty 4 – #6 Phillips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

3 – Installation

The Boltwood Cloud Sensor III must have a clear view of the sky overhead, and unobstructed air flow. It can be installed a pole, fence post, etc. It is also possible to install it on a roof soffit, 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

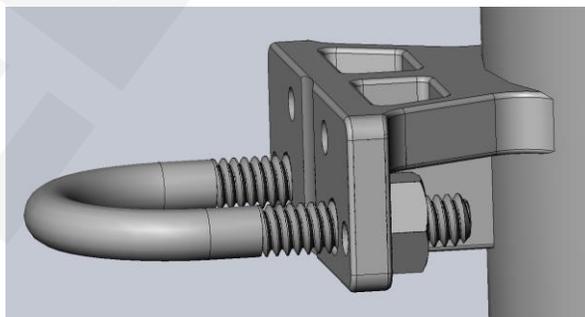


The sensor head can be directly bolted to a flat object. There are four 0.17” (4.3 mm) holes, with pairs available at 0.9” (22.9 mm) and 1.9” (48.3 mm) spacings. These holes will accommodate a #6 or M4 bolt.

There are also two ¼” (6.4 mm) on a 1” spacing (25.4 mm), which will accommodate ¼” or M5 bolt.

Pole Mounting

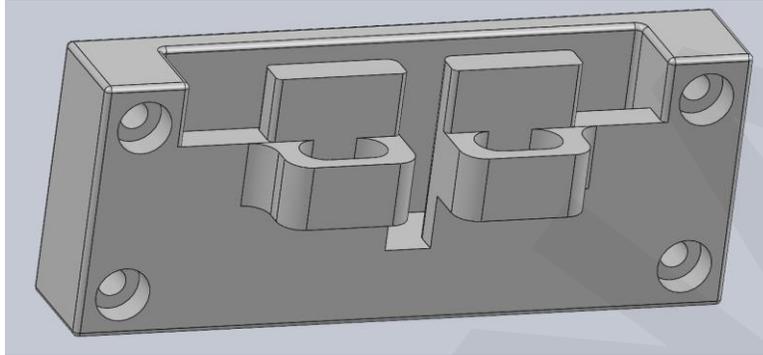
The sensor is supplied with a 1” (25.4 mm) pole mount U-bolt. Simply arrange the U-bolt over the mounting pole and through the mounting bracket, and then attach the supplied nuts. Tighten the nuts sufficiently to anchor the sensor head, but do not overtighten.



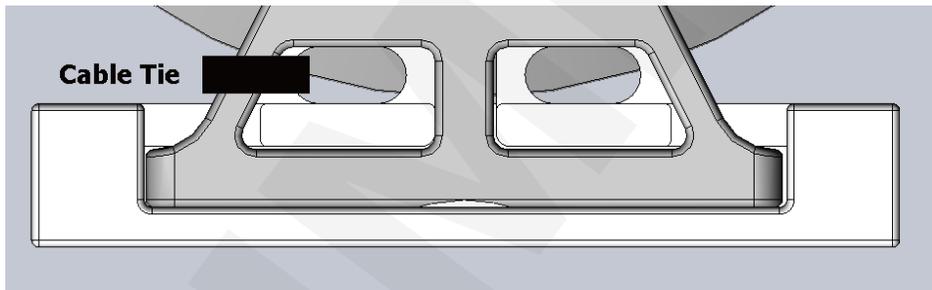
Quick Mount Bracket

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

Using the supplied Phillips head screws, simply screw the bracket onto the post. 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 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 ID / 5.5 mm OD "bullet" connector, which plugs into the bottom of the cloud sensor. Be sure to tie off the cable with a suitable 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 is to be connected (not included), it plugs into the bottom of the sensor head. It requires an industry standard 1.3 mm ID / 3.5 mm OD bullet connector (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 battery backup).

4 – Network Setup

Cloud Sensor ID and Default Password

The Cloud Sensor will identify itself on the network using its serial number. This includes both the Access Point SSID and the name of the unit displayed when connected to a WiFi network.

The default Setup password for the sensor is also the serial number. It will be in the format BCS3123456.

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

Note: Should you lose your password, you can reset it using the see [Master Reset](#) procedure, described below.

Access Point

When the Boltwood Cloud Sensor III is powered up for the first time, it will default to Access Point mode.

The Access Point can be accessed from a smartphone or notebook computer. Go to your network connections and search for networks – the sensor will use its serial number as its SSID (Network ID). Connect to that network.

Next, open your web browser and enter 192.168.10.1. This will bring up the sensor's main web page.

<photo here>

You can fully operate the sensor from the Access Point, but most users will want to connect it to their WiFi network; see below for more information.

Any device connecting directly to the access point will be able to see the weather conditions information; however, changing any cloud sensor settings requires a password.

Wireless Network Setup

On the main web page (see above), select Setup. You will need to enter your password to change the settings.

On the setup page, click Network Settings, and enter the SSID and Password for your wireless network. The sensor will immediately look for the network and connect to it. This will take a few seconds.

The sensor will identify itself on the network using its serial number.

The access point will still work, so if there is something wrong with the SSID or Password you entered, you will be able to try again.

If the network ever goes down the sensor will continuously try to reconnect. 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 local network as follows:

```
<Your BCS serial number>.local
```

Your serial number will be in the format BCS3123456. This identification method allows multiple cloud sensors to be used on the same network.

The Clarity III software (see below) will automatically search for your cloud sensor and identify its IP address, if needed.

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

```
tracert <Your BCS serial number>.local
```

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

Master Reset

If you manage to lose your password or have network connection problems, it is possible to reset the unit to factory default using a magnet. Factory default will revert the sensor to Access Point mode only, and reset the password to the sensor's serial number.

Look at the sensor from the front (side opposite the mounting bracket). You will see the Boltwood logo. There is a magnetic switch directly behind the first "O". With power applied to the sensor, hold a magnet against this spot for several seconds. The unit will reset the network settings to default Access Point mode with the cloud sensor's serial number used for both the SSID and the setup page password.



Master Reset Location

5 – Software Operation

Clarity III

Clarity III is currently supported on Windows 7 and higher.

Clarity III is included on the supplied Flash Drive. It can also be downloaded from <https://diffractionlimited.com> – please see the Boltwood Cloud Sensor III product page, Downloads tab.

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

Clarity III does several things:

- 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 browser)
- Generates a “one line file”, similar to that produced by the previous Boltwood Cloud Sensor II, for compatibility with certain older software

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. The logs are stored in the folder:

```
Documents\Clarity III
```

ZIP the folder and upload the file to our technical support forum, as explained in the [Technical Support](#) section.

We strongly recommend always running the Clarity III software if a suitable computer is available on your network. It will provide continuous logging of your weather data, and technical data on the performance of the cloud sensor.

Web Browser

The web browser screens allow you to view weather information, and configure the sensor’s thresholds, network settings, etc. This same view is available via the Clarity III software.

If you expose this interface outside your network, we strongly recommend using a strong password for the setup functions.

The web browser view has several pages:

- Status – displays important weather data and other parameters
- Setup – controls the thresholds for detecting unsafe conditions and audible alarms
- WiFi Setup – set the network ID and password
- About – display information on the cloud sensor, and also provides a firmware update capability

ASCOM Alpaca

The most common way to operate this sensor is through its ASCOM Alpaca interfaces. For more information on ASCOM please visit:

<https://ascom-standards.org>

The Boltwood Cloud Sensor III provides two interfaces:

- ISafetyMonitor
- IObservingConditions

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 0 if dark, 10 if twilight, 100 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.

MaxIm DL Pro

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

Firmware Update

The firmware can be updated over-the-air using the web browser interface or the Clarity III software. The upload feature is available when you select About on the main menu.

In the event the software is somehow “bricked”, there is a way to restore the unit; if needed, please contact technical support for assistance.

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 create one. Otherwise log in with your username and password.

Next, click on **Cyanogen Hardware (Public)**, 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 above, for information on how to run the logging software and collect log data.

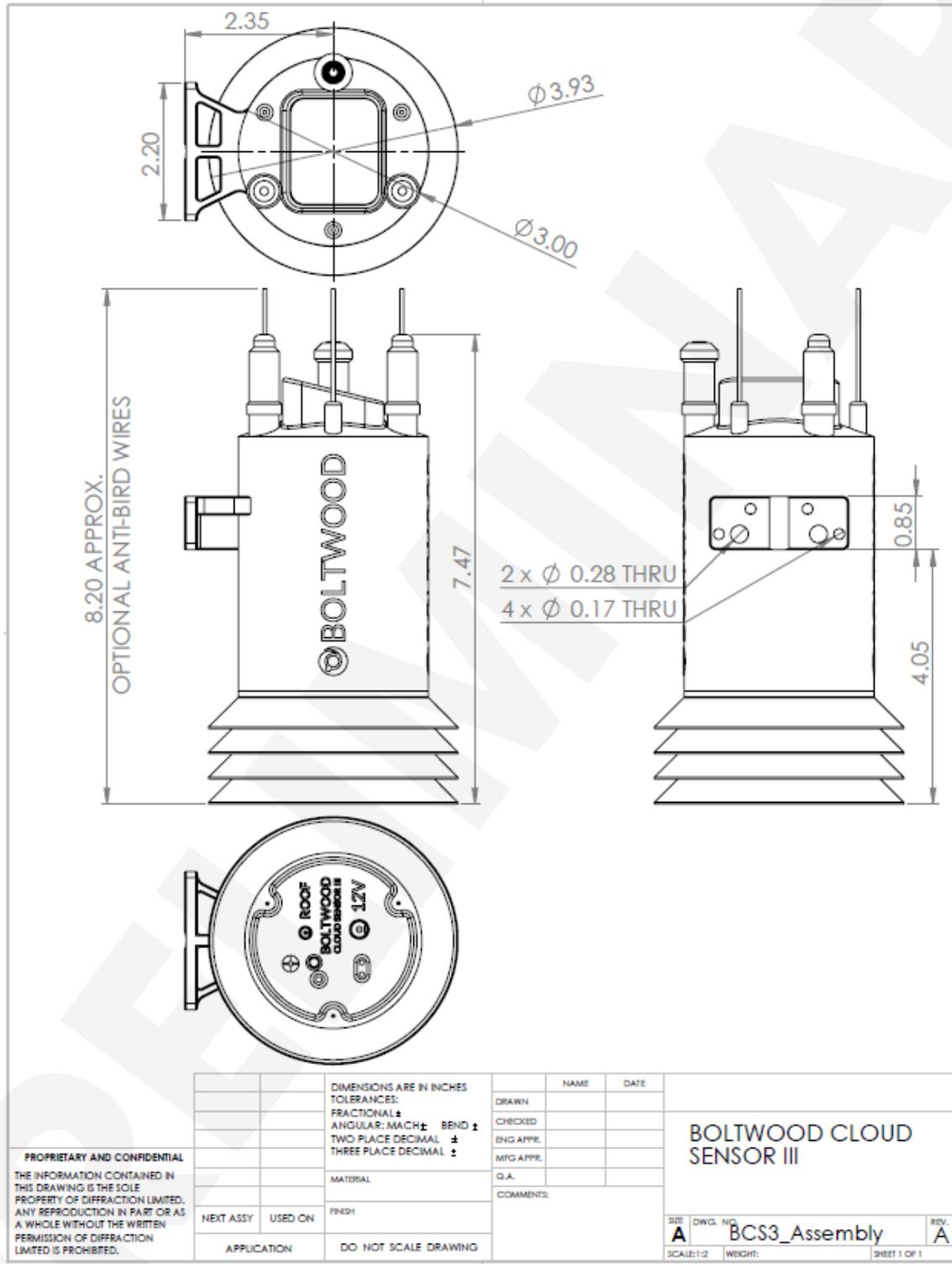
8 – Specifications

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	-40C to +55C 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
WiFi Communications	IEEE802.11b/g/n
Center Frequency Range	2412 ~ 2484 MHz
Country Policy	Automatic configuration based on network station

The power connector is unpolarized – 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.

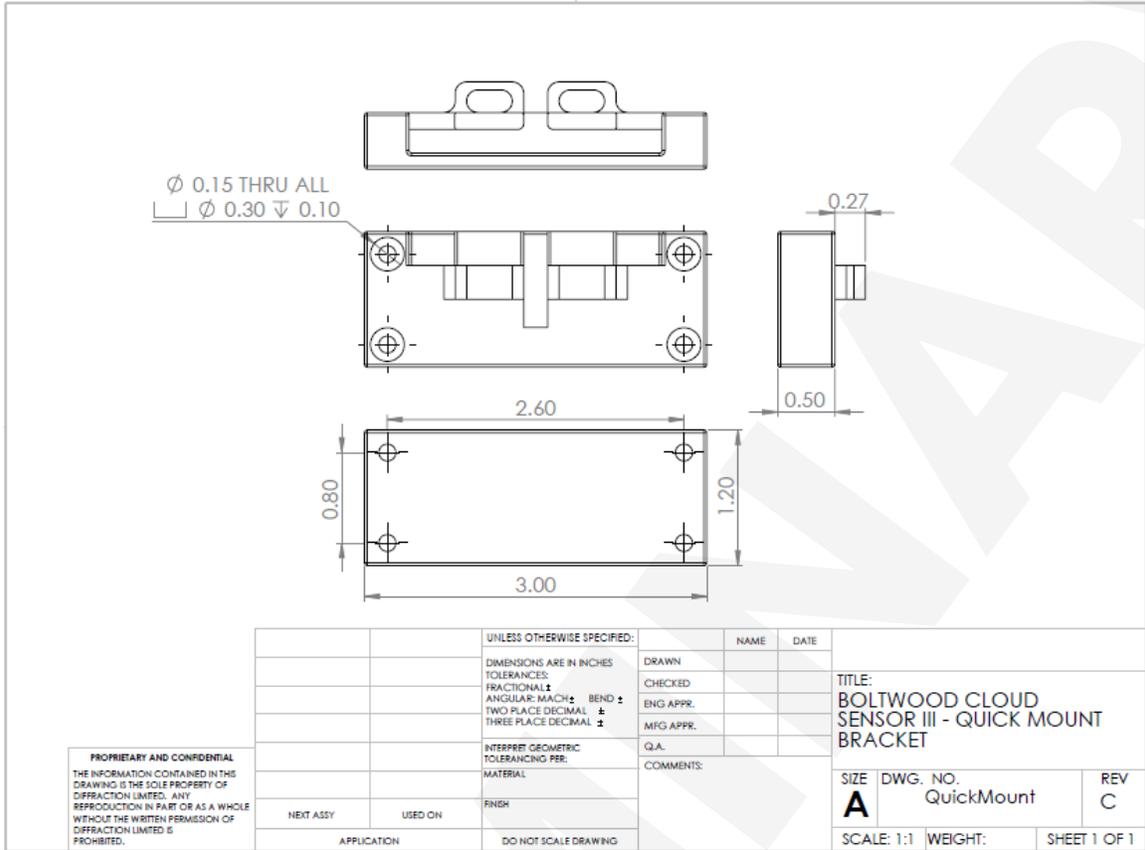
9 – Drawings



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BOLTWOOD CLOUD SENSOR III			
SIZE	DWG. NO.	REV.	
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			A	QuickMount	C
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