O3 Sensor Hub 2.0

BACnet Application Guide

Document version: 1.0

Contents

Introduction

This guide describes the BACnet objects associated with the O3 Sensor Hub 2.0. These objects are used to represent the sensor hub's sensor and device properties and can be accessed and configured by BACnet front-end software.

The O3 Sensor Hub 2.0 is compatible with Delta Controls' enteliWEB software version 4.16 and later.

The information in this guide applies to the following sensor hub models:

- O3-HUB2
- O3-HUB2-2xP

Note: Some features listed in this document may only be available in select models or firmware versions.

About the O3 Sensor Hub 2.0

The O3 Sensor Hub 2.0 is a ceiling-mounted multisensor device that integrates temperature, humidity, motion, sound, and light sensing. Using sensor fusion technology and machine learning algorithms, the sensor hub delivers fast, accurate feedback on the monitored space.

The sensor hub supports BACnet, MQTT, REST, and Bluetooth® Low Energy (BLE) protocols, allowing it to integrate with almost any system. Select models are equipped with two universal I/O points for controlling or accepting inputs from nearby devices.

Other features include:

- dual Ethernet ports for daisy-chaining over large areas
- pass-through communication during power loss
- a full-color customizable LED light ring
- user feedback via speaker

For more information about the sensor hub, go to support.o3hub.com.

BACnet Objects in the Sensor Hub

BACnet objects are used to represent the sensor hub's sensor and device properties. The objects can be grouped as follows.

Sensor

- Temperature
- Humidity
- Occupancy
- Environmental
- I/O (2xP models)

Device

- Light Ring
- Sounds
- Bluetooth
- Firmware
- Other

The following tables list the default BACnet objects for the sensor hub.

Sensor Objects

TABLE 1: TEMPERATURE OBJECTS

Name	Instance	Description
Occupant Temperature	AI3	Temperature at 1 m (3 ft) above the floor. This is a composite value derived from the sensor hub's internal temperature sensors and the IR temperature sensor. Range: 0°C to 59°C (32°F to 138°F).
IR Temperature	AI4	Average temperature of surfaces in the sensor hub's field of view. Range: 0°C to 59°C (32°F to 138°F).
Internal Temperature	AI5	Temperature at ceiling height. Range: 0°C to 59°C (32°F to 138°F).
Temperature Setpoint	AV33	User-entered temperature from mobile app. Measured by user at occupant height.
Celsius	AIC1	Temperature unit of measurement.
Fahrenheit	AIC2	Temperature unit of measurement.

TABLE 2: HUMIDITY OBJECTS

Name	Instance	Description
Occupant Humidity	AI6	Humidity at 1 m (3 ft) above floor. This is calculated from the occupant temperature and internal humidity using psychrometrics. Range: 0% to 100%.
Internal Humidity	AI7	Humidity at ceiling height. Range: 0% to 100%.

TABLE 3: OCCUPANCY OBJECTS

Name	Instance	Description
Occupancy	BI8	Combined (motion + sound) occupancy signal. Active state when motion and sound is detected. See How Occupancy Works for more details.
Motion Sensor	BI9	Motion occupancy signal. Active state when motion is detected.
Acoustic Activity Level	AI10	Audio level after certain frequencies are filtered out.
Acoustic Occupancy	BI11	Acoustic occupancy signal. Active state when acoustic activity level (AI10) is above the internal acoustic occupancy threshold (AV38).
Motion Sensitivity	AV23	Controls the sensitivity of the PIR sensor to changes in movement levels within the detection area. 100% = maximum sensitivity.
Occupancy Audio Sensitivity	AV24	Controls the sensitivity of the acoustic occupancy sensor to changes in audio levels within the detection area. 100% = maximum sensitivity.

TABLE 3: OCCUPANCY OBJECTS

Name	Instance	Description
Occupancy Audio Retrigger Period	AV25	The amount of time (in seconds) that activity sounds can cause the hub to remain in the occupied state after motion is detected. Default value is 1200 seconds (20 minutes). Measured from most recent motion detection event.
Occupancy Inactivity Period	AV26	The amount of time (in seconds) it takes the sensor hub to return to the unoccupied state when no motion and no audio activity is detected. Default value is 300 seconds (5 minutes).
Occupancy Audio Update Period	AV27	Update period (in seconds) for the baseline microphone levels to adjust to environmental changes when no occupants are present. Default value is 30 seconds.
Acoustic Occupancy Threshold	AV38	The acoustic activity level based on the background noise level. Read-only.
Occupancy Remaining Latch Time	AV39	The amount of time (in seconds) remaining before the combined occupancy signal (BI8) deactivates. Read-only.

TABLE 4: ENVIRONMENTAL OBJECTS

Name	Instance	Description
Light Level	AI12	Brightness of ambient light (lx or ft-candle).
Color Temperature	AI13	Color temperature of ambient light (K).
Light Sensor Red Component	AI14	Red component of ambient light. Range: 0 to 65535.
Light Sensor Green Component	AI15	Green component of ambient light. Range: 0 to 65535.
Light Sensor Blue Component	AI16	Blue component of ambient light. Range: 0 to 65535.

TABLE 4: ENVIRONMENTAL OBJECTS

Name	Instance	Description
Sound Level	AI17	Level of ambient noise (dB SPL). Unfiltered audio level across the entire spectrum.
Thermal Load	AI18	*Not currently supported.*
Light Level Setpoint	AV34	(Optional) User-entered light level from mobile app. Records the light level read by the hub (AI12) when the lighting in the space is set to the desired brightness. This setpoint can be retrieved later by the control system to set the feedback loop, etc.
Lux	AIC3	Light level unit of measurement.
Footcandles	AIC4	Light level unit of measurement.
16bit Scale	AIC5	Analog-to-digital unit of measurement.
Decibel	AIC6	Sound level unit of measurement.
Kelvin	AIC7	Color temperature unit of measurement.

TABLE 5: I/O OBJECTS (2XP MODELS ONLY)

Name	Instance	Description
Universal IO Channel 1 AI	AI1	Displays analog input value on I/O point xP1.
Universal IO Channel 1 BI	BI1	Displays binary input value on I/O point xP1.
Universal IO Channel 1 AO	AO1	Displays analog output value on I/O point xP1.
Universal IO Channel 1 BO	BO1	Displays binary output value on I/O point xP1.
Universal IO Channel 2 AI	AI2	Displays analog input value on I/O point xP2.
Universal IO Channel 2 BI	BI2	Displays binary input value on I/O point xP2.
Universal IO Channel 2 AO	AO2	Displays analog output value on I/O point xP2.
Universal IO Channel 2 BO	BO2	Displays binary output value on I/O point xP2.

Device Objects

TABLE 6: LIGHT RING OBJECTS

Name	Instance	Description
Play Light Ring Pattern	MV1	Plays light ring pattern (1-13). Default value is 1 (Off). See Light Ring Patterns for more details.
Light Ring Pattern Repeats	AV2	Sets number of times light ring pattern repeats.
Light Ring Custom Color Red	AV3	Sets red component of light ring RGB value. Range: 0% to 100%. Only valid if BV7 is On.
Light Ring Custom Color Green	AV4	Sets green component of light ring RGB value. Range: 0% to 100%. Only valid if BV7 is On.
Light Ring Custom Color Blue	AV5	Sets blue component of light ring RGB value. Range: 0% to 100%. Only valid if BV7 is On.
Light Ring Brightness	AV6	Sets overall brightness of light ring. Range: 0% to 100%. Default value is 50%.
Light Ring Activate Custom Colors	BV7	Activates custom light ring color defined by Light Ring Custom Color Red (AV3), Light Ring Custom Color Green (AV4), and Light Ring Custom Color Blue (AV5). When set to On, it overrides Play Light Ring Pattern (MV1).
Power On Self Test Enable	BV8	Activates power-on self-test (POST), which tests sensor, Bluetooth, and Ethernet functionality. POST status is indicated by the following colors: green = OK, red = sensor problem, blue = Bluetooth problem, and yellow = Ethernet problem.
Light Ring Patterns	MIC1	Contains 12 light ring patterns. See Light Ring Patterns for more details.

TABLE 7: SOUND OBJECTS

Name	Instance	Description
Play Sound	MV28	Plays a sound. There are 25 default sounds, contained in MIC2. You can also create up to 25 custom sounds. See Loading Custom Sounds for more details.
Sound Repeats	AV29	Sets the number of times a sound is played.
Sound Volume	AV30	Sets the speaker volume in the range 0-100. Default value is 0 (Off).
Startup Sound Enable	BV44	Enables "Power On" sound to play when the sensor hub restarts. Default value is Off.
Default Sounds	MIC2	Contains 25 default sounds (FIL101 to FIL125). These sounds cannot be overwritten.

TABLE 8: BLUETOOTH OBJECTS

Name	Instance	Description
Enable BLE	BV31	Enables Bluetooth LE communication.
Bluetooth Beacon MAC Address	CSV32	Displays MAC address of Bluetooth LE beacon.
Bluetooth Maximum Transmit Power	MV40	Sets the strength of Bluetooth LE beacon. There are 8 maximum allowable transmit power states. Not valid if BV31 is Off.
BLE PIN	CSV45	Sets the 6-digit authentication code for read/write access via Bluetooth. Default value is 000000.
Bluetooth Transmit Power	MIC4	Contains 8 transmit power states (-40, -20, -16, -12, -8, -4, 0, 4 dBm).

TABLE 9: FIRMWARE OBJECTS

Name	Instance	Description
Firmware Info	CSV41	Displays current firmware version and build.
Firmware Upgrade	CSV43	Initiates a firmware upgrade. See Upgrading the Firmware for more details.

TABLE 10: OTHER DEVICE OBJECTS

Name	Instance	Description
NTP Enable	BV42	Sets time to Coordinated Universal Time (UTC) when connected to the internet. See Disabling NTP for more details.
MQTT Password	CSV46	Sets the MQTT internal broker password. See Changing the MQTT Broker Password for more details.

How Occupancy Works

A state change from unoccupied to occupied is triggered when a combination of motion and sound is detected in the room. Sound by itself does not trigger a state change.

The occupied state is extended when additional motion *or* sound is detected in the room. The ambient sound level must be above the baseline audio level that the sensor hub has previously established. Activity sounds detected after the Occupancy Audio Retrigger Period (**AV25**) do not extend the occupied state. This reduces artificial extension of the occupied state by background noise.

If no additional motion or sound is detected after the Occupancy Inactivity Period (**AV26**), the sensor hub reports the room as unoccupied. The ambient sound level must be below the baseline audio level that the sensor hub has previously established.

Light Ring Patterns

The following light ring patterns are defined by the **MIC1** (Light Ring Patterns) object. The states are supplied to the **MV1** (Play Light Ring Pattern) object.

State	Name	Description	Factory Color
1	Idle (Off)	No pattern is displayed.	None
2	Blue Swirl	Light circles ring once, followed by two short flashes, followed by long flash.	Blue
3	Fast Blue Swirl	Same as above but faster.	Blue
4	Power On	Light circles ring three times.	Green
5	Occupancy Active	Light circles ring three times.	White
6	Got Request	Three short flashes.	Green
7	Heating Active	Light ring fades in and out.	Red
8	Cooling Active	Light ring fades in and out.	Blue
9	Don't Understand	Four short flashes, followed by long flash.	Yellow
10	Error	Eight short flashes.	Red
11	Alarm	Sixteen short flashes on alternating sides of ring.	Red
12	Christmas	Sixteen short flashes in alternating colors.	Red and green
13	Awake and Waiting	Light circles ring once, followed by long flash.	Blue

Default Sounds

The following default sounds are defined by the **MIC2** (Default Sounds) object. The states are supplied to the **MV28** (Play Sounds) object. States 2 to 26 correspond to **FIL101** to **FIL125**.

1. Idle (Off)
2. Power On
3. Acknowledge
4. Chime Confirm
5. Ding
6. Reminder
7. Occupancy 01
8. Occupancy 02
9. Cooling
10. Heating
11. Alarm
12. Critical Alarm
13. Error
14. Alert
15. Security Alarm
16. Notification
17. Prompt
18. Question
19. Done
20. Short Cancel
21. Short Confirm Yes
22. Short Off
23. Short On
24. TNG Door
25. Scanning
26. Ambient Alert

Setting Up the Sensor Hub

This section covers the following topics:

Security Settings

Changing the MQTT Broker Password

The sensor hub has an internal MQTT broker that allows you to write directly to the hub's configuration file. The default username/password to access the broker is `user`/`admin`. To secure writes to the internal MQTT broker, you must change this password. *It is important to do this even if you don't plan to use MQTT.*

The MQTT broker password is case-sensitive and must be 5 to 31 characters in length. Special characters are allowed.

To change the password:

1. Create object **CSV46** with the name "MQTT Password".
2. Command the object to manual mode and enter the new password as the object value.
3. Restart the sensor hub. If you're using enteliWEB, on the object list page, click **Device Actions** > **Reset**.

Note: The **CSV46** object value should clear after the new password is entered. If it doesn't clear, the password was not accepted. Check the password length and try again.

Changing the BLE PIN

The BLE PIN is a 6-digit code used to authenticate Bluetooth-enabled mobile devices. To secure writes to the sensor hub via Bluetooth, you must change the BLE PIN after the initial configuration with the O3 Setup app is complete.

The BLE PIN must consist of digits between 0 and 9 and must be exactly 6 digits in length. The new PIN cannot be 000000.

To change the PIN:

1. Create object **CSV45** with the name "BLE PIN".
2. Command the object to manual mode and enter the new PIN as the object value.
3. Restart the sensor hub. If you're using enteliWEB, on the object list page, click **Device Actions** > **Reset**.

Note: The **CSV45** object value should clear after the new PIN is entered. If it doesn't clear, the PIN was not accepted. Check the PIN length and try again.

Disabling Bluetooth

Another way to secure writes to the sensor hub via Bluetooth is to disable Bluetooth LE communication on the hub.

To disable Bluetooth:

1. Command object **BV31** (Enable BLE) to manual mode and set the object value to **Off**.
2. Restart the sensor hub. If you're using enteliWEB, on the object list page, click **Device Actions** > **Reset**.

Configuration Settings

Upgrading the Firmware

If the sensor hub has an active internet connection, you can get firmware updates from the default URL.

Note: The sensor hub must have the correct time for the firmware upgrade to work. Before continuing, make sure object **BV42** (NTP Enable) is set to **On**.

To upgrade a single sensor hub:

1. Create object **CSV43** with the name "Firmware Upgrade".
2. Command the object to manual mode and enter the firmware version as the object value. Use the following JSON format: `{"version": "FIRMWARE_VERSION"}`

To batch upgrade multiple sensor hubs using enteliWEB:

1. Create object **CSV43** with the name "Firmware Upgrade".
2. In the left pane, hold down the Shift key and select up to 8 sensor hubs that you want to update.
3. Filter on **CSV43**.
4. Select the checkbox at the top left to select all the objects.
5. Click **Command > Manual Value**, then enter the firmware version as the object value. Use the following JSON format: `{"version": "FIRMWARE_VERSION"}`
6. Click **Save**.

When the sensor hub receives the upgrade command, it validates the server URL and firmware build before proceeding. If the validation check fails, the light ring on the hub will flash red 8 times. If the validation check is successful, the light ring turns orange to indicate that the upgrade is in progress. The upgrade may take several minutes.

If the firmware upgrade fails for any reason, the light ring will flash red 8 times, after which the hub will pause for 8 seconds, then retry upgrading. It will retry upgrading up to 3 times.

Note: If the upgrade command is sent simultaneously to multiple sensor hubs in a daisy chain, some downstream hubs may fail to upgrade if there are interruptions in the network. Verify the upgrade result in the **CSV41** object value and repeat the process if necessary.

Once the upgrade process is complete, verify that **CSV43** has cleared its value. The new firmware version should be displayed in the **CSV41** (Firmware Info) object value.

Calibrating the Occupant Temperature

The sensor hub models the room temperature at occupant height using its internal temperature sensors and IR temperature sensor. Because each room is different (due to air flow, heating sources, height of the ceiling, etc.), the hub's initial prediction is likely to be slightly off. This difference can be calibrated out by measuring the current room temperature below the hub and sending that value to the hub. The offset is calculated automatically.

For best results, observe the following guidelines:

- Try to get the room temperature as close to your setpoint as reasonably possible. The calibration should hold within ± 5°C, but the closer you are to the control point the better it will be.
- Make sure the temperature in the space has been reasonably stable for at least 15 minutes. That is, don't go from 10°C to 20°C and then calibrate the reading as soon as you reach 20°C. Hold at approximately 20°C for 15 minutes and then calibrate.
- Try to calibrate within the hub's IR envelope, but also make sure it isn't directly next to a heating or cooling source.
- Calibrate at approximately 1 m (3 ft) off the floor.

Normally, the occupant temperature is calibrated using the O3 Setup mobile app. However, you can also update the calibration value over BACnet.

To update the calibration value:

1. Open object **AI3** (Occupant Temperature).
2. Set the object to manual mode.
3. Enter the new calibration value in the **Calibration** field and save your changes.

Note: If **AI3** is not set to manual mode, the entered value will be discarded and the previous calibration value will be shown after a refresh.

Changing Network Settings

The sensor hub supports both BACnet over Ethernet (BACnet/Ethernet) and BACnet over UDP/IP (BACnet/IP). By default, the BACnet protocol type is set to BACnet/Ethernet. To change the protocol type, connect to the hub over BACnet/Ethernet and configure the BACnet/IP settings.

To configure BACnet/IP settings in enteliWEB:

1. Open object **NP6** (Ethernet1 - IP1).
2. Clear the **Out Of Service** checkbox.
3. Leave the **UDP Port** number as the default value (47808) unless you want to create independent groups of BACnet devices on the same IP subnet.
4. Set **IP Mode** to **Foreign** if you want the hub to join a BACnet/IP network with a different IP subnet address. Otherwise, leave it as **Normal**.
5. If **IP Mode** is set to **Foreign**, in the **BBMD Address** field, enter the IP address of the BACnet Broadcast Management Device (BBMD) that you want to register with, then enter the **Subscription Lifetime** (Time-To-Live) value. This is the interval at which the hub must re-register with the BBMD to keep participating on the BACnet/IP network.
6. Click **Save**. The message "Changes Pending" appears at the top of the page.
7. Return to the object list page and click **Device Actions** > **Activate Network Change**.

Note: The O3-HUB2 does not route and cannot function as a BBMD.

Disabling NTP

Network Time Protocol (NTP) service is enabled by default, which allows the sensor hub to synchronize with Coordinated Universal Time (UTC) time when connected to the internet.

Note: Time zone offsets are not currently supported by the firmware. If you are using enteliWEB, you cannot enable the time zone setting in the DEV object.

If you want the hub to get its time from another BACnet device or from enteliWEB, you must disable the NTP service.

To disable NTP:

- Command object **BV42** (NTP Enable) to manual mode and set the object value to **Off**.

Enabling a Startup Sound

You can enable the "Power On" startup sound to play when the sensor hub is restarted. By default, this option is disabled.

To enable the startup sound:

1. Command object **BV44** (Startup Sound Enable) to manual mode and set the object value to **On**.
2. Restart the sensor hub to verify that the sound plays. If you're using enteliWEB, on the object list page, click **Device Actions** > **Reset**.

Custom Settings

Creating a Custom Light Ring Color

The light ring consists of red, green, and blue LEDs. You can create custom colors by adjusting the intensity of the component LEDs.

To create a custom light ring color:

1. Command object **BV7** (Light Ring Activate Custom Colors) to manual mode and set the object value to **On**.
2. Open one or more of the following objects: **AV3** (Light Ring Custom Color Red), **AV4** (Light Ring Custom Color Green), or **AV5** (Light Ring Custom Color Blue).
3. Set the object(s) to manual mode.
4. For each object, enter an object value between **0** (Off) and **100** (full intensity) and save your changes.

Possible light ring color settings include the following:

Color	AV3 (Red)	AV4 (Green)	AV5 (Blue)
Red	100	0	0
Green	0	100	0
Blue	0	0	100
Cool White	100	100	50
Yellow	100	50	0
Orange	100	25	0
Pink	100	0	25
Teal	0	100	50

The light ring displays the custom color until object **BV7** is set to **Off**.

Note: Light ring commands are processed in the following order: Sensor hub status display **BV8** (highest priority) > Light ring brightness **AV6** > Activate custom light ring color **BV7** > Play light ring pattern **MV1** (lowest priority).

Loading Custom Sounds

You can load up to 25 custom sounds, saved as WAV files, to the sensor hub. Each sound file should not exceed 1 MB. The total number and size of custom sounds supported will depend on the amount of remaining free space in the system.

To load custom sounds to the sensor hub:

1. Create a FIL object for each audio file, with instances between 126 and 150.
2. Open each FIL object and upload the audio file that you want to associate with that FIL.
3. Create a new MIC object where state 0 is Idle and states 1 to *xx* correspond to the custom sounds (**FIL126** to **FIL1*xx***). Alternatively, update the existing **MIC2** object and add states 26 to *xx* for the custom sounds (**FIL126** to **FIL1*xx***).

To play a sound, command object **MV28** (Play Sound) to manual mode and set the object value to the sound you want to play. For example, "**1. Power On**".

Creating Programs

Although the sensor hub itself does not support Program (PG) objects, you can control the hub's light ring and/or sounds remotely using GCL+ code executed on a BACnet system controller.

For example, you could write a program to activate the light ring and play a sound when motion is detected. If the sensor hub has a BACnet Device_Instance property (Device Number or Device ID) of 1503, the GCL+ code on the system controller might look something like this:

```
//play light ring and sound on hub motion detection
IfOnce 1503.BI9 Then
1503.MV1 = 5 //play "occupancy active" light ring
1503.MV28 = 7 //play "occupancy sound"
End If
```

Revision History

Version	Date	Description
1.0	January 8, 2021	New document.