

M8 Sensor User Guide



Notices

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Revision History

Version	Date	What Changed
A	12/04/15	Released.
B	03/25/16	Complete revision: Updated fonts, most sections, GPS/IMU module list, and Figure 1, Figure 4, Figure 7, Figure 14, Figure 21, Figure 41, Figure 51. Added Tables 1-3, Figure 16, Figure 15, Figure 23, and back cover.
C	08/25/16	Complete revision for sensor Rev B1: Fixed errors (Table 3, Figure 23). Updated figures and contact information. Added ISO certification, VMware procedures for SDK, NMEA input signal, sensor M12 3-pin connector, and manufacturing label. Rearranged sections to improve procedural flow.
D	10/31/16	Updated for sensor Rev C. Added legal caution (p7). Updated Table 4, Table 5, cleaning procedure (p64), and PPS/NMEA configuration text. Moved sensor integration procedure via VM/SDK to <i>Sensor SDK User Guide for Ubuntu</i> .
E	11/28/16	Updated "Packets" section for sensor Rev C, removed legacy "Access SDK" and "Check Network" sections, improved Appendix 1, added Appendix 3.
F	03/24/17	Complete revision for sensor Rev D1, amending Figure 23 to show new counter-clockwise laser firing configuration. Added overview of Q-View tool, Figure 2, Figure 3, Figure 4, Figure 19, Figure 20, Figure 22, and Table 14. Changed most M8-1 designations to refer to product family (M8) rather than specific model number (M8-1). Added URLs for downloadable documents. Updated front/back matter, "Physical Safety" and "Getting Started" sections, Appendix 3, Figure 1, Figure 4, Figure 7, Figure 21, Figure 51, Table 1, and Table 3. Fixed frame rate and references to the MAC address. Omitted the Complete Minimal Working System table.
G	04/17/17	Revised sensor Rev D1 startup procedures because the sensor is now factory-delivered in a static IP configuration, and added Figure 18 and Figure 20 Sensor Static IP Address.
H	07/31/17	Updated for sensor Rev D3, with new multi-return feature (Figure 5). Updated "Introducing the Sensor," Table 4, Table 5, Figure 1, Figure 7, Figure 20, Figure 21, Figure 22, Figure 51, and Figure 52 due to improved manufacturing label, consistent IP addresses, and depiction of beam angles. Updated Troubleshooting section, referring to sensor diagnostics and versions. Updated Table 3, Appendix 1 list of Quanergy-supported GPS/IMU modules. Amended the M8 sensor voltage range in Appendix 3.

Version	Date	What Changed
J	04/27/18	Updated for sensor Rev D4: better network connectivity, sensor startup. Updated for sensor Rev D5: better near range and intensity (21), options for reduced power/bandwidth (47-48), status indicators (54), remote reboot (58). Omitted documents roadmap, ceiling-mounted scenario, and QPU references. Revised ripple power (16), Appendix 1 (66), and Appendix 2 (77). Added "ASTM G154" (12), M8 models (19), "Power over Ethernet" (17), "Intensity" (21), cross-talk prevention (26), "Managing the Sensor" (formerly <i>M8 Sensor Settings User Guide</i>) (38-60), sensor-mounting accessories (77-85), end-of-life Q&A (87), and Index (88).
K	08/31/18	Updated for sensor Rev D4 with patch updating Base firmware to 7.03. Added trademarks to the Notices (2) and Pulse Width specs in Table 12 (67). Updated Intensity (21), web server (38, 47, 48, 54, 58), static IP reset (59-60), and software status definitions in Table 11 (62-64).

Contents

Notices.....	2
Contact	2
Follow Us!	2
Revision History.....	3
Contents	5
Figures	9
Tables	10
Important Safety Notices	11
Caution!	11
Operating Safety.....	11
Physical Safety	11
Compliances	12
ASTM G154	12
CE Compliance.....	12
FCC Compliance	12
FDA Compliance	12
IEC/EN Safety Compliance	13
IP69K Compliance	13
RoHS Compliance	13
WEEE Compliance	13
1. Getting Started	14
M8 Sensor.....	14
Complete Minimal Working System	15
Interface Cable	15
Power Source.....	16
<i>Proper Disconnect</i>	16
<i>Power Supply</i>	16
<i>Power over Ethernet</i>	17
Computing Environment with Tools and Solutions.....	17
User-Provided Items.....	18
Support Documents.....	18
2. Introducing the Sensor.....	19
Applications	19
Features	19
Models.....	19
NMEA and PPS Inputs.....	19
Multiple Returns.....	20
Evaluation Rules	20
Intensity	21

3. Mounting the Sensor.....	22
Options.....	23
Scenarios	23
Vehicle Grill-Mounted Scenario	23
Vehicle Rack-Mounted Scenario.....	24
Indoor Tripod-Mounted Scenario	24
Side-Mounted on Drone Scenario	25
Wall-Mounted Security Scenario	25
Multi-Sensor Scenario.....	26
Connectors and Pins	27
4. Integrating the Sensor	29
Connect the Sensor	29
Find the Serial Number and IP Address	31
Hardware Label Reveals Serial Number	31
Q-View Software Reveals Serial Number and IP Address.....	31
M8 Sensor Settings Management Application Reveals Serial Number and Versions	32
Terminal Command Reveals Serial Number and IP Address.....	32
5. Getting TCP Ethernet Packets	33
Variable Definitions.....	33
For All Three Returns.....	34
For Reduced Return	35
Timestamp	36
Laser Firing	36
Beam Angles.....	36
6. Managing the Sensor	38
Introducing the Web Server	39
Opening the Web Server	40
M8 Sensor Tab.....	42
Login.....	42
Welcome	43
Settings Tab.....	44
Edit Settings	44
Frame Rate	44
Scan Field	46
Low Power Spinup	47
Return Data Select	48
Ring Settings	48
GPS Settings	49
Reset Settings.....	50
Edit Network.....	51
Admin Tab	52

My Account Tab.....	53
Change Password.....	53
editor Logout.....	54
Status Tab.....	54
Versions Tab.....	56
Reboot Tab.....	58
Reset a Static IP Address.....	59
Closing the Web Server.....	60
7. Taking the Next Steps.....	61
8. Stopping the Sensor	61
Shut Down	61
Restart.....	61
9. Troubleshooting Issues	62
Check the Status	62
Perform Cleaning.....	64
Resolve an Issue.....	64
Check an Issue	64
Report an Issue	65
Appendix 1: Use of NMEA/PPS Signals.....	66
Concepts and Specifications.....	66
Purpose of NMEA.....	66
Purpose of PPS	67
Electrical Interface and Transmission Settings.....	67
Mechanical Interface	68
Data Communication	69
\$GPRMC NMEA Sentence	69
\$GPZDA NMEA Sentence.....	70
Procedures.....	71
Connect Single Sensor to the GPS Receiver.....	71
Connect Multiple Sensors to the GPS Receiver.....	72
Configure the GPS Settings	73
PPS Signal.....	74
NMEA Signal.....	74
Baud Rate Synchronization.....	74
Synchronize Sensor with GPS Timestamp.....	74
Windows or Ubuntu Without ROS Driver.....	74
Ubuntu With ROS Driver.....	74
Check the GPS Signal Lock	76
For M8 Sensor Rev D5.....	76

Appendix 2: Sensor Mounting and Accessories	77
Sensor Dimensions.....	77
Base Plate Dimensions.....	78
Accessory for Mounting	78
Accessory for Weather Shielding	79
Installation of Accessories	80
Gather Resources	80
Apply Force	80
Determine Which Mounting Surface.....	80
<i>Mounting to a Pole</i>	<i>81</i>
<i>Mounting to a Flat Surface.....</i>	<i>82</i>
Address Environmental Concerns	83
<i>With the Adjustable Mount.....</i>	<i>83</i>
<i>Without the Adjustable Mount</i>	<i>83</i>
Add the Sensor.....	84
Adjust Pitch and Roll	84
<i>Pitch Adjustment.....</i>	<i>84</i>
<i>Roll Adjustment.....</i>	<i>84</i>
Appendix 3: Frequently Asked Questions.....	86
Index.....	88

Figures

Figure 1. Sensor Manufacturing Labels.....	14
Figure 2. Sensor Interface Cable Provided with M12 IP67-Rated Female Connector.....	15
Figure 3. AC/DC Power Adapter (bottom) and Cable (top).....	16
Figure 4. M8 LiDAR Sensor.....	19
Figure 5. Sensor Emitting a Single Beam (for example) with Multiple Returns	20
Figure 6. Point Cloud Produced by M8 Sensor Rev D5 Reveals Intensity.....	21
Figure 7. Permanent Mounting Base (round), Detachable Base Plate (rectangular).....	22
Figure 8. Vehicle Grill-Mounted Sensor	23
Figure 9. Vehicle Rack-Mounted Sensor with User's Custom Base Plate.....	24
Figure 10. Indoor Tripod-Mounted Sensor with Detachable, Rectangular Base Plate	24
Figure 11. Drone with Side-Mounted Sensor	25
Figure 12. Wall-Mounted for Security	25
Figure 13. Multi-Sensor Scenario	26
Figure 14. Sensor Cable M19 (left), Interface M19 (center), Interface Sub-Cables (right)	27
Figure 15. Sensor Cable Connector Wire Color (left), J1/J2/Sub-Cable Connectivity (right)	27
Figure 16. M19 Pinout and Photo	28
Figure 17. M12 3-Pin Pinout and Photo	28
Figure 18. Sensor Connections with Static IP Address	29
Figure 19. Sensor Connections with Dynamic IP Address	30
Figure 20. Sensor Serial Number on Detachable Base Plate (left), Mounting Base (right)	31
Figure 21. Finding the Sensor IP Address from the Command Line, Pinging Sensor	32
Figure 22. Laser Beam Angles	36
Figure 23. Laser Firing Position (Top-Down View).....	37
Figure 24. Creating a Network on Non-Ubuntu Machine.....	40
Figure 25. Creating a Network on Windows 7 Machine.....	41
Figure 26. Web Server: M8 Sensor Tab's Login Mode.....	42
Figure 27. Web Server: M8 Sensor Tab's Welcome Mode.....	43
Figure 28. Web Server: Settings Tab's Menu Items	44
Figure 29. Web Server: Settings Tab's M8 Settings Edit (top), Rings (right), GPS (bottom).....	45
Figure 30. Usage-Based Sensor Placement Improves Results	46
Figure 31. Web Server: Settings Tab's Reset Message (left), Reboot Message (right).....	50
Figure 32. Web Server: Settings Tab's Network Settings (left), Static IP (bottom), Reboot (top).....	52
Figure 33. Web Server: Admin Tab.....	52
Figure 34. Web Server: My Account Tab's Change Password and editor Logout Items.....	53
Figure 35. Web Server: My Account Tab's Change Passwords Fields.....	53
Figure 36. Web Server: M8 Status Tab	54
Figure 37. Web Server: M8 Sensor Status Tab's Report.....	55
Figure 38. Web Server: Versions Tab's Report of Associated Software.....	56
Figure 39. Web Server: Reboot Tab's Confirmation Page.....	58
Figure 40. Creating a Network Environment for Fail Safe Mode.....	59
Figure 41. Power Indicator on the AC/DC Power Adapter.....	64

Figure 42. View Sensor through IR Scope (left) to See Sensor Flash+Reflection (right)	65
Figure 43. NMEA/PPS Input Voltages.....	68
Figure 44. NMEA/PPS/Ground Communication	68
Figure 45. NMEA/PPS Signals Synchronized on Single Sensor	71
Figure 46. NMEA/PPS Signals Synchronized on Multiple Sensors.....	72
Figure 47. NMEA/PPS Signals Distributed by PRL-414B-BNC Buffer Amplifier	72
Figure 48. Normal Alignment: Positive PPS (top), Active Low NMEA (bottom)	73
Figure 49. Web Server: GPS Settings.....	73
Figure 50. Web Server: Status Tab Report for GPS and UTC Timestamp.....	76
Figure 51. M8 Sensor Mounting Drawing of Sensor.....	77
Figure 52. M8 Sensor Mounting Drawing of Rectangular Base Plate	78
Figure 53. M8 Sensor Adjustable Mount Accessory	78
Figure 54. M8 Sensor Weather Shield Accessory	79
Figure 55. Adjustable Mount's Pole Clamp.....	81
Figure 56. Adjustable Mount's Back Plate.....	82
Figure 57. Weather Shield Installation	83
Figure 58. Adjustable Mount's Roll Adjustments	85
Figure 59. Adjustable Mount's Pitch Adjustments	85

Tables

Table 1. M8 Sensor.....	14
Table 2. AC/DC Power Adapter Specifications	16
Table 3. User-Provided Items.....	18
Table 4. Variable Definitions for M8 Packet	34
Table 5. Variable Definitions for the Packet Data.....	34
Table 6. Variable Definitions for M8 Packet	35
Table 7. Variable Definitions for the Packet Data.....	35
Table 8. Features Introduced in Each Revision of the Sensor (M8) and Web Server (WS)	38
Table 9. Web Server: Scan Field Specifications Based on Sensor Placement.....	47
Table 10. Web Server: M8 Software Version Definitions.....	57
Table 11. Web Server: M8 Software Status Definitions.....	62
Table 12. Electrical and Transmission Specifications.....	67
Table 13. NMEA \$GPRMC Sentence Decoded.....	69
Table 14. NMEA \$GPZDA Sentence Decoded	70

Important Safety Notices

Caution!

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Do not open the sensor!

Per terms of sale, purchaser agrees to not reverse assemble, disassemble, or modify the sensor, nor to allow a third party to do so.

Operating Safety



The exclamation point icon alerts the reader to the presence of general safety warnings as well as important operating and maintenance instructions in the product documentation.

1. **Read** all safety and operating instructions before operating the product.
2. **Retain** all safety and operating instructions for future reference.
3. **Follow** all warnings and operating instructions on the product and in the operating instructions.
4. **Service** tasks are for authorized support representatives only. Do not attempt to modify or service the product.

Physical Safety

The M8™ LiDAR sensor has achieved compliance with several certifying agencies.



Do not modify the unit, remove its cover, disassemble it, or attempt to service it. No scheduled maintenance is necessary to keep the product in compliance.

If there are visible defects or damage to the M8 LiDAR sensor, contact your service representative for all service or repair issues, or questions about safety. Refer *all* servicing and repairs of the sensor to authorized support representatives.

Compliances

Quanergy's M8 LiDAR sensor has been tested and found to comply with the standards and specifications of several organizations.

ASTM G154

This product complies with standard practices for operating fluorescent Ultraviolet (UV) lamp apparatus in the exposure of nonmetallic materials. Tests reproduced and measured the weathering effects that occur when materials are exposed to sunlight, either directly or through window glass.

CE Compliance

This product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation as stated in the Harmonized Standards, which are the technical specifications established by European standards agencies, including CEN and CENELEC.

FCC Compliance

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: FCC Part 15B/ICES-003/EN 61326-1 Class B testing and report. 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 equipment and receiver.
- 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.

FDA Compliance

The M8 LiDAR sensor is designated Class 1 (eye safe) during all procedures of operation, having satisfied IEC AEL and MPE emission requirements per IEC 60825-1 8.4F and 13.3. Complies with US FDA performance standards for laser products except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007. CLASS 1 LASER PRODUCT EN/IEC 60825-1 Ed 3 2014, E.U. & JAPAN IEC 60825-1 Ed 2 2007 USA.



IEC/EN Safety Compliance

The M8 LiDAR sensor passed rigorous safety testing in compliance with IEC/EN 61010-1-2010 Safety Standard by ensuring full safety and protection against electric shock, fire or burns and mechanical hazards. IEC/EN 61010-1-2010 Safety Standard provides added value for the CE marking and recognition well beyond European countries.

The M8 LiDAR sensor was assessed to meet applicable requirements per the IEC60079-15 standard for ensuring that an electrical apparatus is sufficiently protected from igniting a surrounding explosive gas atmosphere.

IP69K Compliance

The M8 LiDAR sensor passed Water and Dirt/Dust Ingress Tests in compliance with the IEC 60529 IP69K specification.

RoHS Compliance

Bills of Material components of Quanergy's 3D M8 LiDAR sensor have been reviewed for RoHS2 and found to be in compliance with the European Union (EU) Directive EU RoHS-2 Directive 2011/65/eu.

WEEE Compliance

The 3D M8 LiDAR sensor has been reviewed and analyzed through WEEE Recovery, Reuse, Recycle and found to be in compliance with the European Union (EU) Directive for Waste Electrical and Electronic Equipment (WEEE).

NOTE: RoHS and WEEE Requirements pertain to Restriction of Hazardous Substances (6/6) Compliance with Environmental procedure 020499-00, primarily focused on Restriction of Hazardous Substances (ROHS Directive 2002/95/EC) and Waste Electrical and Electronic Equipment (WEEE Directive 2002/96/EC). The six hazardous and restricted substances in the RoHS2 directive as outlined in Annex II with maximum concentration values tolerated by weight to homogeneous materials are: Lead (0.1%), Mercury (0.1%), Cadmium (0.01%), Hexavalent chromium (0.1%), Polybrominated biphenyls (0.1%), and Polybrominated diphenyl ethers (PBDE) (0.1%).

1. Getting Started

The M8 sensor does not operate on its own; it requires a complete system involving additional parts to operate and collect data, as explained in the following subsections. This manual assumes the user will purchase those parts from Quanergy and/or assemble their own for a complete working system.

M8 Sensor

The M8 sensor includes all hardware listed in Table 1, plus two documents: *M8 Sensor Quick Start Card* (<https://quanergy.desk.com/customer/portal/articles/2687032>) and the *Documents* list (<https://quanergy.desk.com/customer/portal/articles/2725667>) of links to additional Quanergy user guides. If any expected item is missing or damaged upon arrival, contact your support representative.

Table 1. M8 Sensor

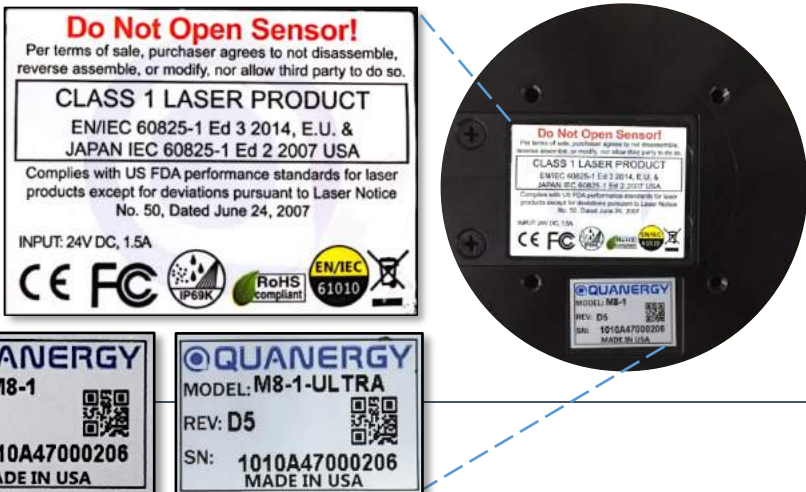
Item	Image
M8 sensor	
Detachable rectangular base plate, which arrives pre-attached to the sensor with four screws	
3-foot sensor cable; one end is permanently wired to the sensor, and the other end is the M19 IP67-rated dust- and water-proof connector (pin assignments are discussed on pages 27-28)	
IP67-rated M19 Female connector if needed to assemble a custom interface cable (pin assignments are discussed on pages 27-28)	
Manufacturing label, which combines three labels (including model Core/Plus/Ultra, revision, and serial number), as shown in Figure 1:	
- Manufacturer Label - Explanatory Label - Certification Label	
  	

Figure 1. Sensor Manufacturing Labels

Complete Minimal Working System

Several items must be provided *in addition* to what is listed in Table 1, but the definition of a complete minimal working M8 LiDAR system depends on how the sensor will be used.

Interface Cable

The M8 sensor cable ends with an M19 IP67-rated dust- and water-proof connector, but the sensor needs to connect to power, the network, and possibly other devices such as a GPS/IMU module. There are two options for completing the cable:

1. Assemble a custom interface cable suited to these cable connections, using the provided M19 IP67-rated connector shown in Table 1 and the specifications in the "Connectors and Pins" section on pages 27-28.
2. Purchase a specialized Quanergy sensor interface cable as shown in Figure 2 (typically 15-foot length, with other lengths available upon request), which connects to the sensor cable, and the other end divides into three sub-cables:
 - *Ethernet* sub-cable with RJ45 connector (attaches to a computer's network port, or to an external Ethernet switch).
 - *Power* sub-cable with ferrule connector (attaches to power adapter; see Table 2).
 - A sub-cable with M12 3-pin connector (attaches to *ground* and *NMEA/PPS* signals from optional user-supplied GPS receiver, as explained in "Appendix 1: Use of NMEA/PPS Signals"). (If it is necessary to construct an additional GPS interface cable, an extra M12 IP67-rated female connector (Figure 2 and pages 27-28) is provided with the sensor interface cable.

Do not cut the cable!

Cutting the permanently attached sensor cable is *not* recommended. Such an alteration may impact the environmental protection of the sensor, void the warranty, and incur additional repair charges.



Figure 2. Sensor Interface Cable Provided with M12 IP67-Rated Female Connector

Power Source

The M8 sensor cannot operate without power. On average, each D5 sensor uses up to 18 watts of power when it is spinning. Here are some options related to power.

Proper Disconnect



Providing power that fails to meet the specifications in Table 2 may damage the M8 sensor system. Disconnect from power properly:

NO: *Never* unplug the cord at the M8 sensor's ferrule power connector (Figure 14 right) or toggle a connected power strip's on/off switch because the current still latent in the cord can shock the sensor.

YES: *Instead*, unplug the sensor at the power source (wall outlet or power strip, for example) or at the M19 connector (Figure 14 left) or simply reboot via the web server's Reboot tab (page 58).

Power Supply

Quanergy does not provide a power supply with the standard sensor system, but you may purchase a 120 VAC to 24 VDC power adapter from Quanergy as shown in Figure 3, which comes with its own power cable to connect the sensor to an outlet.



Figure 3. AC/DC Power Adapter (bottom) and Cable (top)

For development purposes, users may provide power via an appropriate power adapter as specified in Table 2. Make sure the power adapter includes a power indicator (such as the LED shown in Figure 3). This helps you confirm whether power is off, on (glowing steadily), or unreliable/intermittent (blinking). This feedback can be important for your support representative to help you if troubleshooting becomes necessary.

Table 2. AC/DC Power Adapter Specifications

Item	Specification
Output Voltage	24 VDC
Output Current	1.5 A (max)
Protection	Short Circuit Protection, Over Current Protection, Over Voltage Protection
Ripple	150 mV _{p-p} (max)
Hold-Up Time	10 mS (min)
Transient Response	0.5 mS for 50% Load Change (typ)
Load Regulation	± 5% (typ)
EMI Conduction & Radiation	Compliant with EN55022 Class B

Power over Ethernet

Power over Ethernet (PoE) is a single cable solution for both communication and power. The M8 sensor has been operated 100 meters from a power source using IEEE 802.3at (PoE+) compliant PoE source and splitter. The PoE source injects DC power into a CAT5/6 cable. A PoE splitter is used to extract power from the cable.

Proper M8 sensor operation with PoE requires IEEE 802.3at compliant equipment. The following PoE splitters have been used to provide 24 VDC power and an Ethernet connection for an M8 sensor at the end of a 100 meter CAT5/6 cable.

- Planet Technology POE-162S (commercial grade)
- Planet Technology IPOE-162S (industrial grade)

Computing Environment with Tools and Solutions

All software tools and solutions provided by Quanergy are designed for x86-64 architecture on the host computer to adequately enable all or some of the following functionality:

- Discovery and management of the sensor.
- Collection, recording, playback, and visualization of the sensor's data.
- Calibration of multiple sensors mapping the same scene.

The M8 sensor works well with several specific computing environments, as follows.

Simple and Intuitive: No configuration required. Q-View™ is Quanergy's proprietary software-based sensor discovery and management toolkit that enables users to easily visualize a point cloud and calibrate pairs of sensors. Refer to the following documents: *Q-View User Guide* (<https://quanergy.desk.com/customer/portal/articles/2717074>) and the *Q-View Quick Start Card* (<https://quanergy.desk.com/customer/portal/articles/2748632>).

Customized: User-preferred configuration required. For users who need to create their own custom solutions and environments, Quanergy offers a software development kit (SDK). Depending on how the sensor was acquired, you may need to purchase and/or request access to the SDK by emailing your GitHub username to support@quanergy.com with the subject "Request M8 SDK source code." Refer to user guides:

- *Sensor SDK User Guide for Ubuntu* — Quanergy fully supports the open source Ubuntu® 14.04 LTS and 16.04 LTS operating system running natively or virtually via VMware or Oracle VM VirtualBox. <https://quanergy.desk.com/customer/portal/articles/2688864>
- *Sensor SDK User Guide for Windows* — Although Ubuntu is the operating system of choice, the M8 sensor is also compatible with any operating system that is capable of initiating a TCP connection with the sensor. In the Windows® 7 environment, users can visualize a basic point cloud, but cannot immediately manipulate it beyond rotating and zooming unless they write their own software solutions. <https://quanergy.desk.com/customer/portal/articles/2688870>

User-Provided Items

Depending on the computing environment and application requirements, some other items might need to be provided by the user. Some of those have already been mentioned, but they are compiled as a convenient list in Table 3.

Table 3. User-Provided Items

Item	Purpose	Notes
Power Source	Power the sensor	Such as by wall outlet or mobile battery
Power over Ethernet (PoE) Splitter	Single cable solution for both communication and power, IEEE 802.3at (PoE+) compliant	Recommended by Quanergy: Planet Technology POE-162S (commercial) Planet Technology IPOE-162S (industrial)
Mouse + Keyboard + Monitor	Support computing environment	Per user preference
Mounting Surface	Affix the sensor	Vehicle roof rack, camera tripod, etc.
Ethernet Switch + Power Adapter	To handle multiple sensors	Recommended by Quanergy: Netgear ProSafe GS108:
GPS/IMU Module	Report position and supply the NMEA/PPS timing signals	Supported by Quanergy: OXTS RT3003 and VectorNav200

Support Documents

Quanergy offers a suite of documents to aid the user in understanding how to set up and operate the M8 sensor system. Access a list of these and other downloadable documents at <https://quanergy.desk.com/customer/portal/articles/2725667>.

The specific links to the most relevant documents are provided below:

M8 Sensor Data Sheet — <https://quanergy.desk.com/customer/portal/articles/2687054>

M8 Sensor User Guide — <https://quanergy.desk.com/customer/portal/articles/2687038>

M8 Sensor Quick Start Card — <https://quanergy.desk.com/customer/portal/articles/2687032>

Q-View User Guide — <https://quanergy.desk.com/customer/portal/articles/2717074>

Q-View Quick Start Card — <https://quanergy.desk.com/customer/portal/articles/2748632>

Sensor SDK User Guide Ubuntu — <https://quanergy.desk.com/customer/portal/articles/2688864>

Sensor SDK User Guide Windows 7 — <https://quanergy.desk.com/customer/portal/articles/2688870>

2. Introducing the Sensor

Quanergy's Time-of-Flight (TOF) M8 LiDAR sensor (Figure 4) enables new applications in the transportation, industrial automation, 3D mapping and surveying, and security markets.

Linux® and Windows drivers allow for easy configuration, integration, and testing.

The *M8 Sensor Data Sheet* lists the specifications defining the sensor. The latest version can be downloaded from <https://quanergy.desk.com/customer/portal/articles/2687054>.



Figure 4. M8 LiDAR Sensor

Applications

Quanergy's smart sensing technology can be applied to a variety of platforms (e.g., vehicles, production tools, robots, and monitoring stations) to enable rapid 3D detection, measurement, identification, tracking, and classification of items, as well as triggering actions based on real-time scenario analysis supported by advanced perception software.

Features

With a 360° field of view, high accuracy, fine resolution, high reliability, compact size, light weight, and low power consumption, Quanergy's compact M8 LiDAR sensor was designed to meet the demands of challenging real-world applications. In addition, the sensor sees by day or night, with no IR signature needed, and is operational in rain, snow, and dust, with IP69K-rated ingress protection.

Models

The M8 family of LiDAR sensors includes three models to better serve Quanergy's diverse customer base and market applications. Depending on industry requirements, choose a model according to its maximum measurement range. Assuming 80% reflectivity:

- M8-Core has a maximum range of at least 100 meters.
- M8-Plus has a maximum range of at least 150 meters.
- M8-Ultra has a maximum range of at least 200 meters.

NMEA and PPS Inputs

The sensor can be clocked according to the National Marine Electronics Association (NMEA) and pulse-per-second (PPS) inputs via the M12 3-pin connector, as discussed in "Appendix 1: Use of NMEA/PPS Signals."

Multiple Returns

The M8 sensor includes the multiple returns feature that produces an enriched point cloud, which is particularly important for 3D mapping. This feature is possible because each emitted laser pulse can reflect off multiple objects (Figure 5) and return to the LiDAR sensor as one or more *return* pulses. The M8 sensor measures and evaluates the distances and intensities of as many return pulses as there are, follows rules for which particular return values to report, then reports the distances and intensities of up to three of those return values.

Evaluation Rules

The distance and intensity of each return pulse is evaluated to determine which is:

- *Maximum*: Has the highest intensity/amplitude.
- *Second Strongest*: Has the second highest intensity/amplitude.
- *Last*: Has the highest range, that is, the longest time-of-flight from the sensor.

The evaluation rules for assigning these labels are as follows:

- If no return pulses are detected, each of the three return values is 0.
- If one or more return pulses are detected:
 - *Return 0*: The first return value equals *Maximum*.
 - *Return 1*: The second return value equals *Second Strongest*. (But if there was only one return pulse, the return value equals *Maximum*.)
 - *Return 2*: The third return value equals *Last*, which may be equal to *Second Strongest* or *Maximum*.

To select a specific return (0, 1, 2, or All 3), refer to “Return Data Select” on page 48.

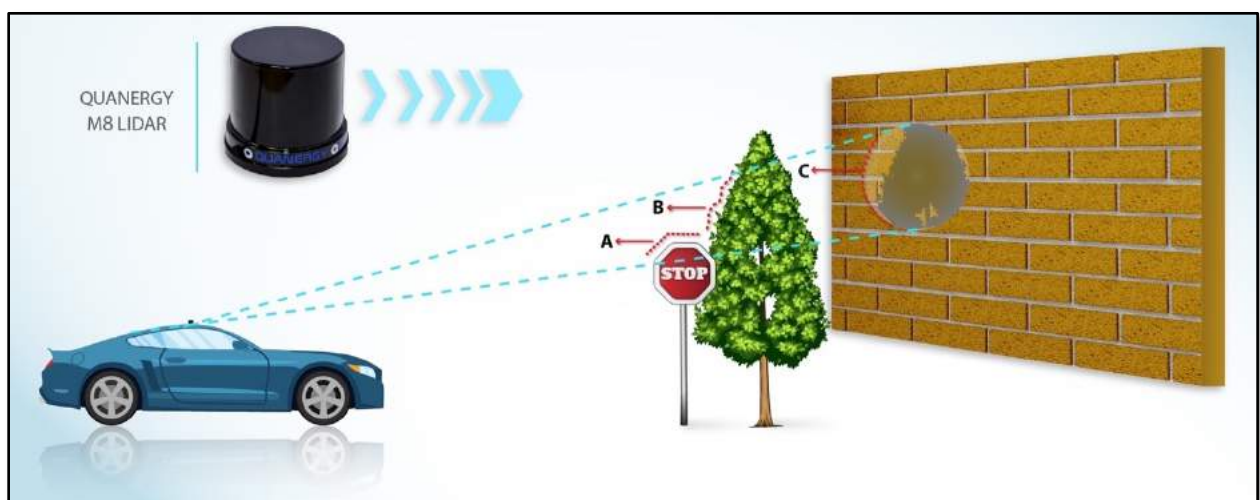


Figure 5. Sensor Emitting a Single Beam (for example) with Multiple Returns

Intensity

Quanergy supports 8-bit intensity for the M8 sensor Rev D5 and up. Intensity is measured on a logarithmic scale related to the reflectivity of a target although other characteristics can affect the value. For visualization, the reported decibel value is assigned a color, which is defined by the user. While computer postprocessing can tease out additional information that is only hinted at in the RViz visualizer, the M8 sensor Rev D5 in Figure 6 clearly shows the distinction in intensity:

- Green points are returns from materials with low reflectivity.
- Blue points are returns from materials with high reflectivity.

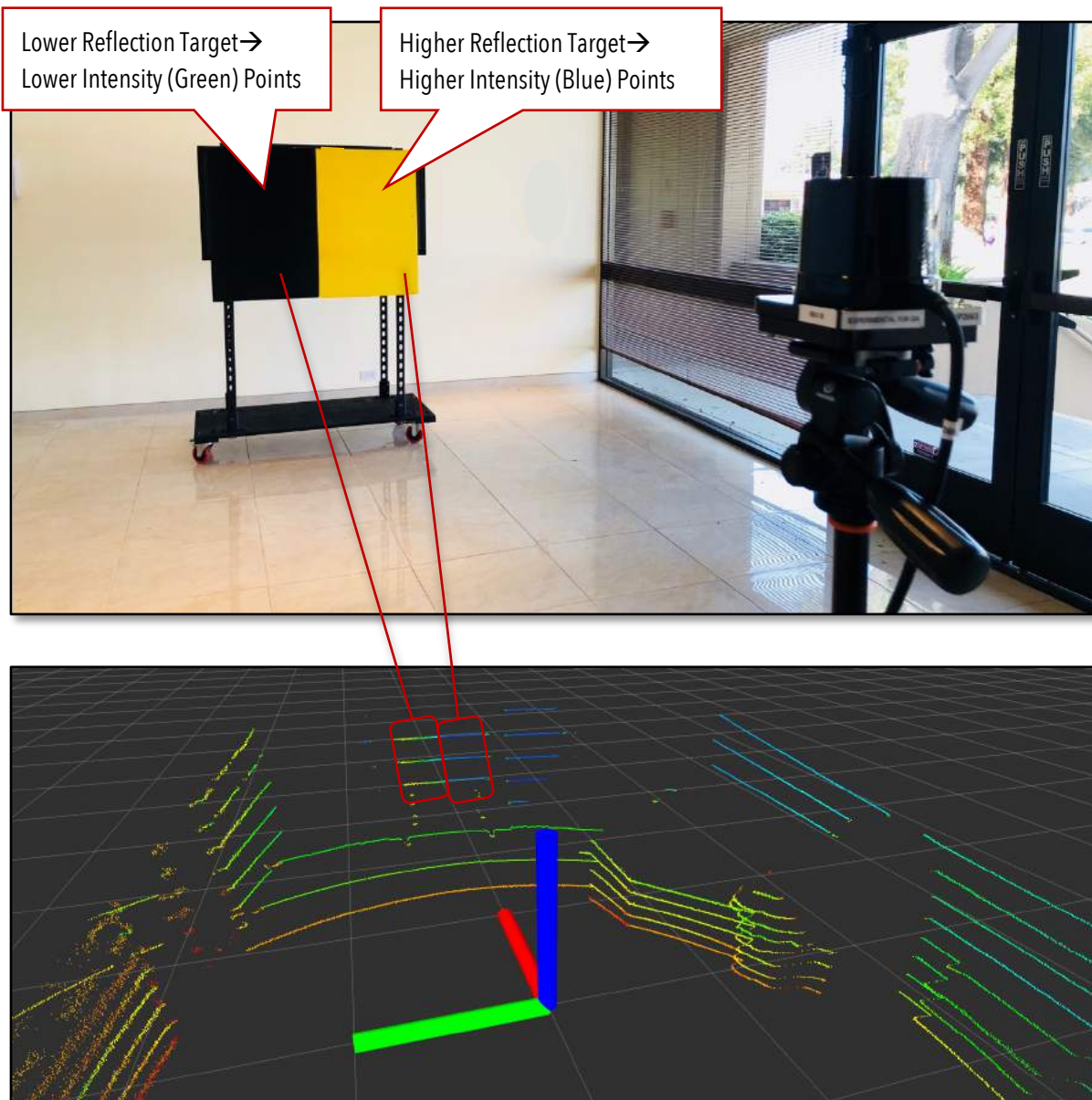


Figure 6. Point Cloud Produced by M8 Sensor Rev D5 Reveals Intensity

3. Mounting the Sensor

The M8 sensor includes the hardware that allows a user to attach it to a preferred surface. The mounting assembly is illustrated in Figure 7. The sensor arrives from the factory securely attached to a **round mounting base** that *must remain attached*. Its four M3 threaded holes are used to mount securely to a surface. A detachable, **rectangular base plate** is screwed into the four holes of the round mounting base. The rectangular base plate provides a platform for the sensor and dissipates heat produced by the sensor's electronics and motor. It must remain attached unless exchanged for an equivalent heat sink. The operating temperature range is -20°C to $+60^{\circ}\text{C}$ (-4°F to $+140^{\circ}\text{F}$).



Customers who remove the detachable base plate (400g aluminum) must substitute a heat sink of similar or greater thermal mass to prevent the sensor from overheating and to enhance its longevity.

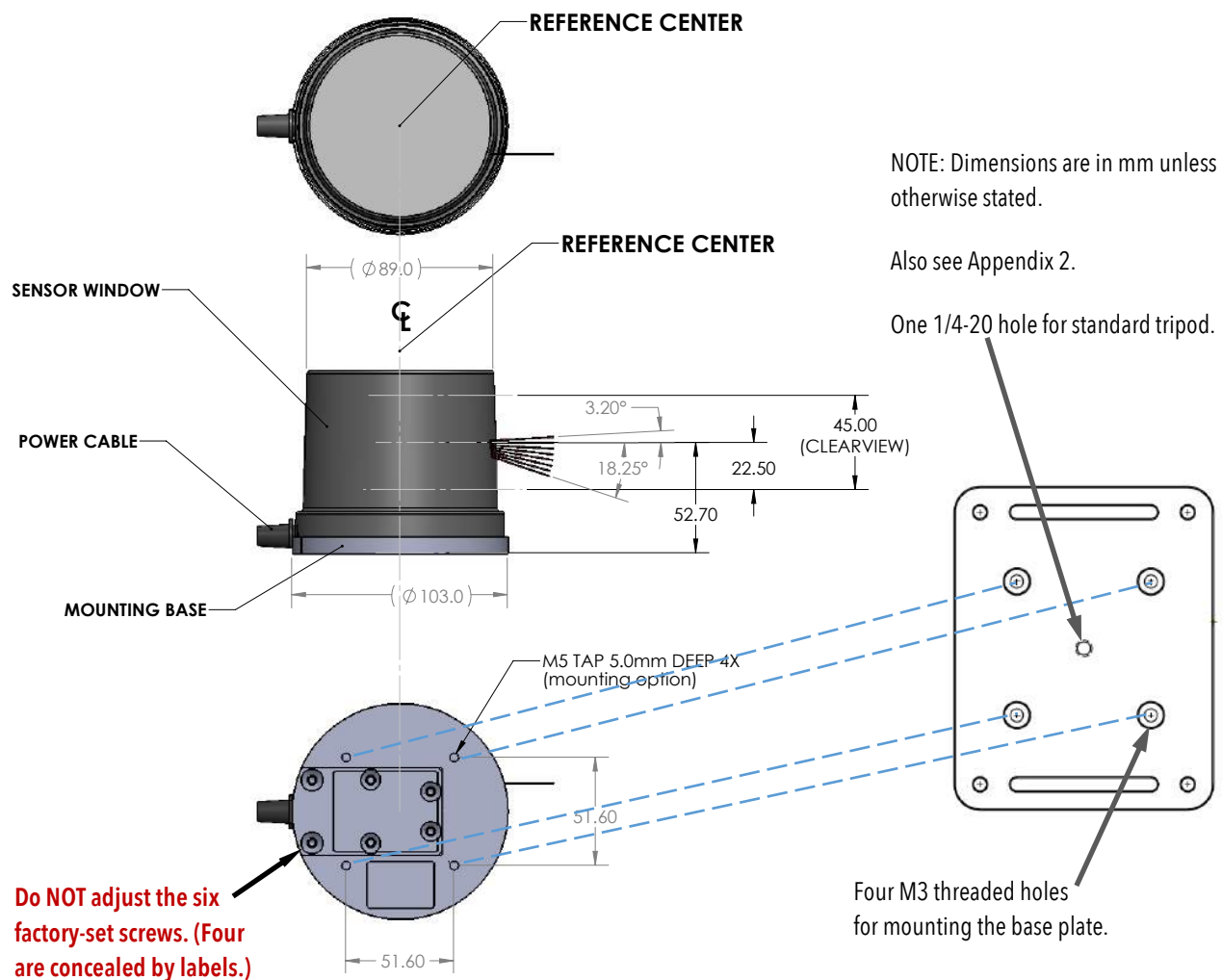


Figure 7. Permanent Mounting Base (round), Detachable Base Plate (rectangular)

Options

Consider how to maximize the number of beams on the area of interest. The sensor can be mounted at any angle and in two general ways, which can be adjusted depending on the user's environment and specifications:

- For use on vehicles, drones, or other outdoor devices, mount the sensor using the four M3 threaded holes in the rectangular base plate (or the round mounting base if the rectangular base plate is removed) for the greatest stability.
- For indoor or bench use, mount the entire assembly (with the rectangular base plate on) to any standard camera tripod via the base plate's center mounting hole, which accommodates the standard tripod screw: 1/4" diameter, 20 threads per inch. Optionally, the four holes in the rectangular base plate or round mounting base could be used to mount the sensor in a customized configuration.

Scenarios

The sensor may be placed in different configurations and at different angles to accommodate specific application needs. Various possible scenarios for installation are depicted as follows. Mounting accessories offered by Quanergy are discussed in "Appendix 2."

Vehicle Grill-Mounted Scenario

Mounting the sensor on a vehicle's grill works well for object detection and safety in vehicle driving. In the Figure 8 example, the rectangular base plate has been detached, and the screws that previously attached it were reused to screw up and through a user-provided custom heat-sink substrate and into the sensor's round mounting base.



Figure 8. Vehicle Grill-Mounted Sensor

Vehicle Rack-Mounted Scenario

Mapping applications may require the sensor to have a higher vantage point. A sensor can mount to a vehicle's roof rack (Figure 9), where the rectangular base plate is replaced with a user-provided custom heat-sink substrate screwed into the sensor's round mounting base.



Figure 9. Vehicle Rack-Mounted Sensor with User's Custom Base Plate

Indoor Tripod-Mounted Scenario

For indoor testing, research, and development, mounting the sensor to a tripod with the detachable, rectangular base plate is a good solution, as shown in Figure 10.

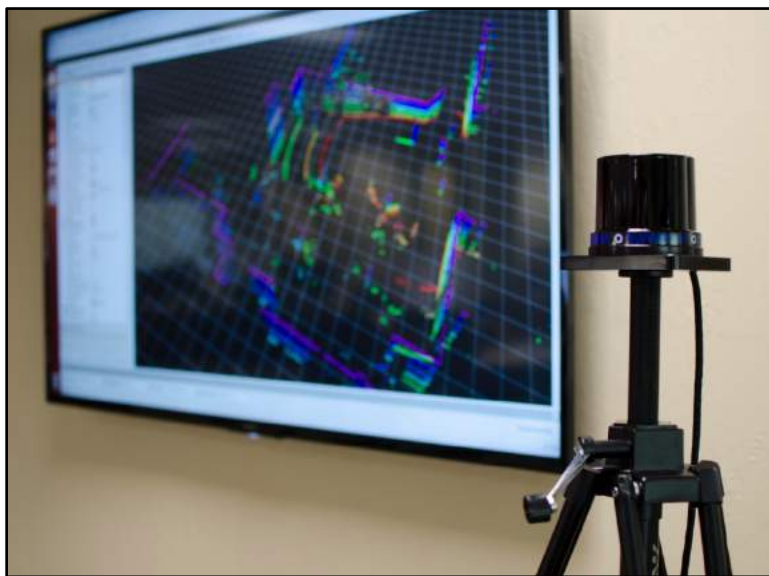


Figure 10. Indoor Tripod-Mounted Sensor with Detachable, Rectangular Base Plate

Side-Mounted on Drone Scenario

The cramped spacing of a drone provides special challenges. In the Figure 11 example, the sensor is mounted to a drone's payload at a 90° angle.



Figure 11. Drone with Side-Mounted Sensor

Wall-Mounted Security Scenario

Figure 12 shows a sensor mounted by a fixture to a wall. The M8 sensor dramatically boosts the surveillance power of a typical video monitoring system, as enabled by Quanergy's security solution. The sensor can be mounted inside or outside, day or night, and is fully operational in any weather, with ingress protection from rain, snow, or dust.



Figure 12. Wall-Mounted for Security

Multi-Sensor Scenario

Some applications such as for vehicle operation or security monitoring use multiple M8 sensors simultaneously to cover a wide area. Figure 13 shows two sensors mounted in close proximity on a vehicle.

Reduce the possibility of cross-talk by:

- Optimizing sensors' mount positions to increase the distance and/or relative angles.
- Installing a simple separation plate (Figure 13), which is typically a plastic barrier, opaque in the IR wavelength of 905 nm.



Figure 13. Multi-Sensor Scenario

Connectors and Pins

The sensor is permanently attached to a 3-foot sensor cable, which features an M19 IP67-rated dust- and water-proof connector (Figure 14 left). This connector attaches to an interface cable, which can be purchased from Quanergy or constructed by the user. Refer to the photo of the specialized interface cable available from Quanergy, which has the female version of the M19 IP67-rated connector on one end (Figure 14 center) and three sub-cables on the other (Figure 14 right). Recommended connectivity is illustrated in the wire color chart in Figure 15, with pin assignments shown in Figure 16 and Figure 17.



Figure 14. Sensor Cable M19 (left), Interface M19 (center), Interface Sub-Cables (right)

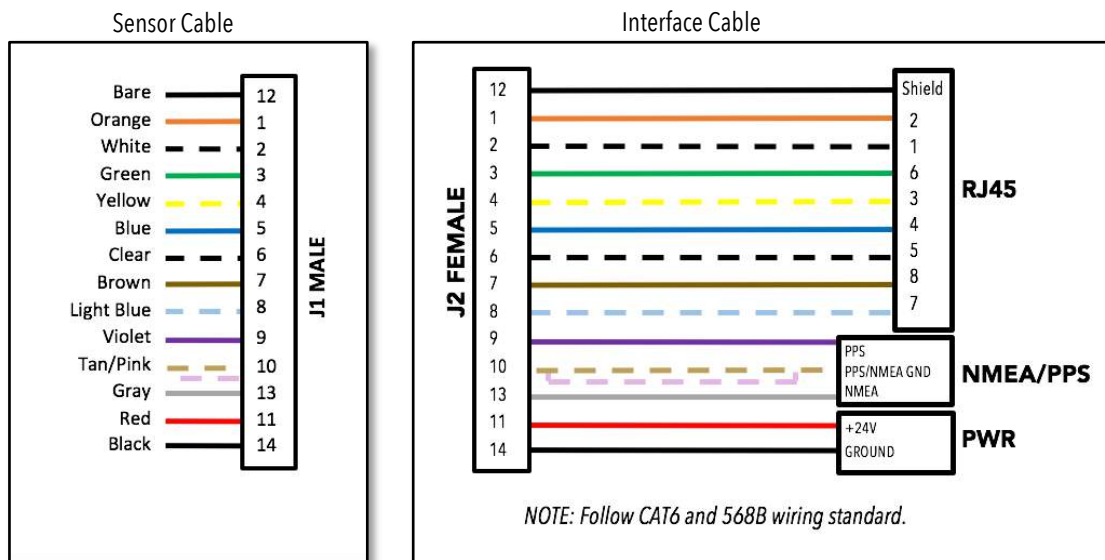


Figure 15. Sensor Cable Connector Wire Color (left), J1/J2/Sub-Cable Connectivity (right)

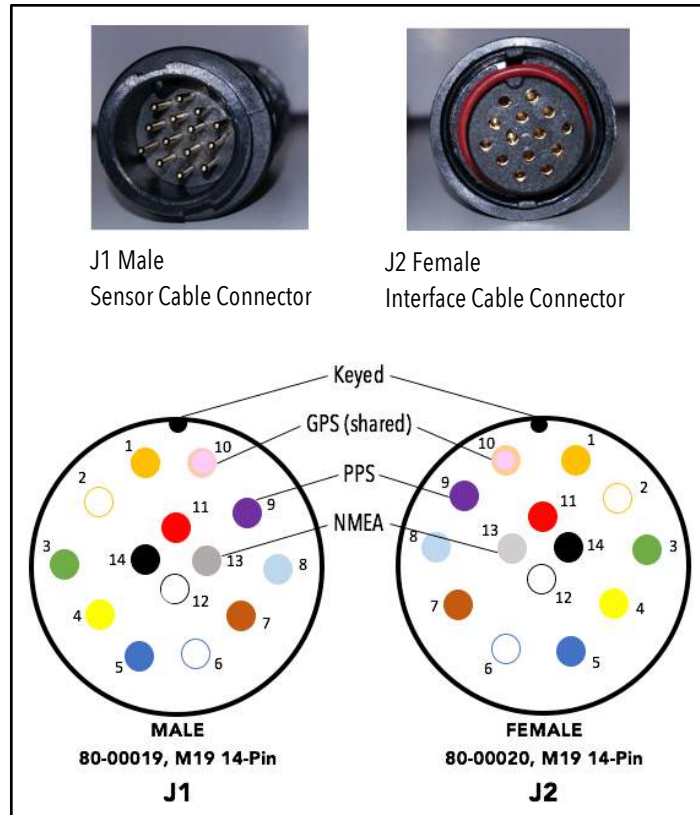


Figure 16. M19 Pinout and Photo

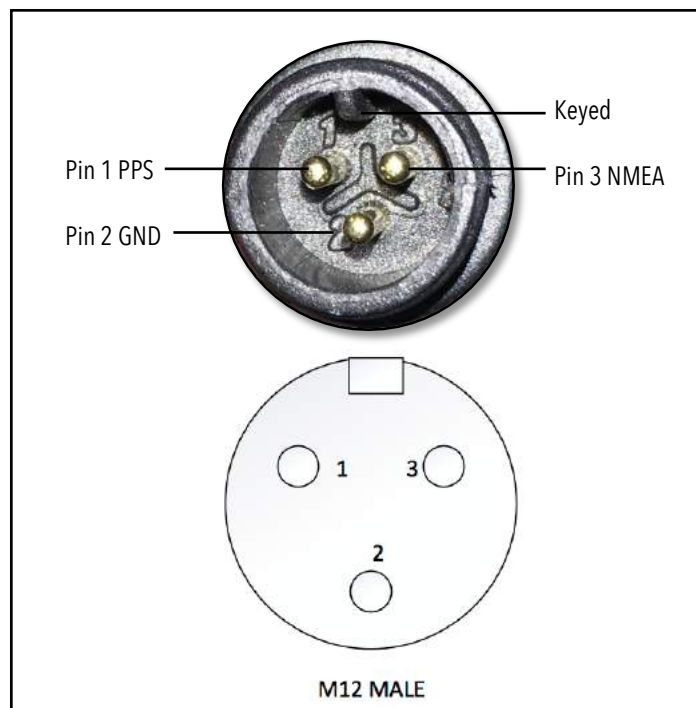


Figure 17. M12 3-Pin Pinout and Photo

4. Integrating the Sensor

Depending on which environment the M8 sensor is integrating into, the specifics of what happens may vary. Refer to the user guide related to your particular computing environment if details in this section are insufficient:

- *Q-View User Guide* - <https://quanergy.desk.com/customer/portal/articles/2717074>
- *Sensor SDK User Guide for Ubuntu* - <https://quanergy.desk.com/customer/portal/articles/2688864>
- *Sensor SDK User Guide for Windows* - <https://quanergy.desk.com/customer/portal/articles/2688870>

Connect the Sensor

Make sure the sensor has a way to connect to power, network, and ground/GPS. M8 sensors arrive from the factory configured with the same static IP address: 192.168.1.3. Update the sensor's IP configuration and connect the sensor to your computing environment as follows:

1. Connect the sensor directly to the host computer's network port (Figure 18).
The sensor is compatible with any operating system that is capable of initiating a TCP connection with the sensor. Quanergy recommends using a host computer that is running Ubuntu 14.04.5 (natively or in a virtual machine) over x86-64 architecture.

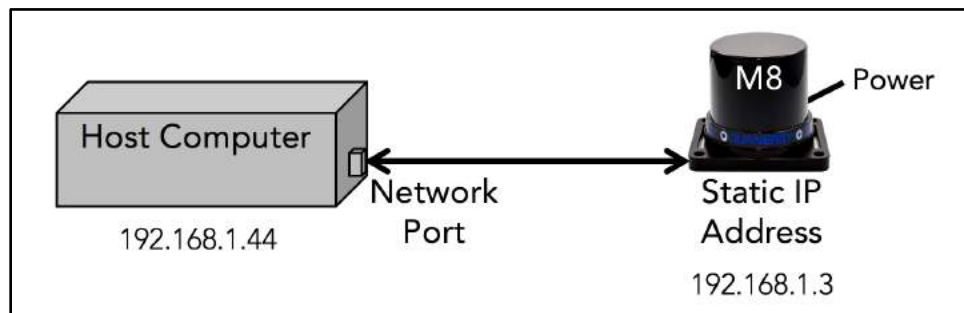


Figure 18. Sensor Connections with Static IP Address

2. Connect the sensor to a power outlet.
3. Open the computer's network preferences panel, and configure the computer's settings:
 - IP Address is 192.168.1.x, where x is any number 7-254 that does not conflict
 - Network Mask is 255.255.255.0
 - Router Gateway is 192.168.1.1

4. All M8 sensors are assigned the same static IP address to start with, so update each of the new sensors (one at a time) to accept dynamic IP addresses, or to have different static IP addresses, as follows:
 - Log into the sensor's web server, as explained in the "Managing the Sensor" section, pages 38-44.
 - Select the *Edit Network* item from the Settings tab, then continue to follow the procedure in the "Edit Network" section on pages 51-52.
 - Before operating the sensor, take some additional steps, depending on whether you configured the sensor to receive a dynamic or a static IP assignment:
 - **For dynamic:** Connect to a router that is on the same network as the host computer (Figure 19). The DHCP server will automatically assign the sensor a dynamic IP address to match the computer's network address.
 - **For static:** Instead of staying directly plugged in (Figure 18), you may connect the sensor to the same network as the host computer.
5. To accept NMEA/PPS inputs, refer to "Appendix 1: Use of NMEA/PPS Signals" in this user guide, and connect to ground/GPS.

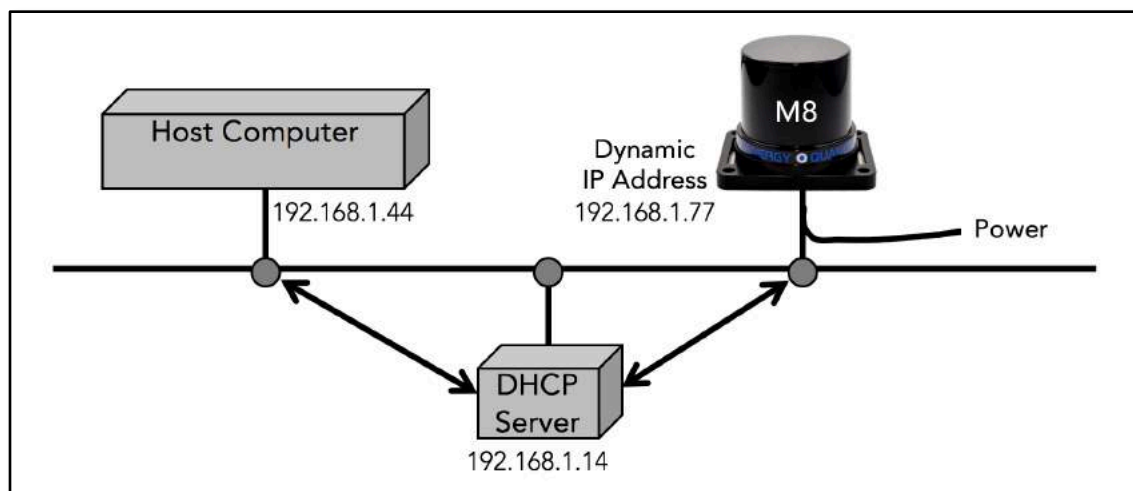


Figure 19. Sensor Connections with Dynamic IP Address

Find the Serial Number and IP Address

There are many times when you need to know the sensor's serial number and IP address. A serial number is permanently associated with the sensor, and it is the key for knowing which IP address belongs to a sensor. An IP address changes over its lifetime. The various methods for discovering a sensor's serial number and IP address are explained in the following subsections.

The IP address, in either dynamic or static assignment, is essential for communicating with the M8 sensor over the Ethernet TCP connection. The "Edit Network" section on page 51 explains in detail how to configure the sensor to accept a static or dynamic IP address.

Hardware Label Reveals Serial Number

Find the serial number on the sensor's hardware sticker labels:

- The sticker on the rectangular base plate (Figure 20 left) has an abbreviated serial number, which is QP and last six digits (without the leading zeroes) of the sensor's MAC address (Figure 21).
- The manufacturing label on the sensor's round mounting base (Figure 20 right) has the full serial number, whose last six digits match the last six digits of the sensor's MAC address (Figure 21).



Figure 20. Sensor Serial Number on Detachable Base Plate (left), Mounting Base (right)

Q-View Software Reveals Serial Number and IP Address

Quanergy's Q-View Sensor Management and Visualization software offers a visual tool to identify sensors that are attached to the same network as Q-View's host computer. This convenient tool reveals each sensor's serial number and IP address. The last six digits of the sensor's MAC address (without leading zeroes) are the sensor's abbreviated serial number. (See the *Q-View User Guide* at <https://quanergy.desk.com/customer/portal/articles/2717074>.)

M8 Sensor Settings Management Application Reveals Serial Number and Versions

If you know a sensor's IP address, you can open the M8 Sensor Settings Management web application ("Managing the Sensor" section starting on page 38), which lists the sensor's complete serial number in the footer of each web page (Figure 27). In addition, the Versions tab (page 56) lists the versions of various software components involved in the M8 sensor.

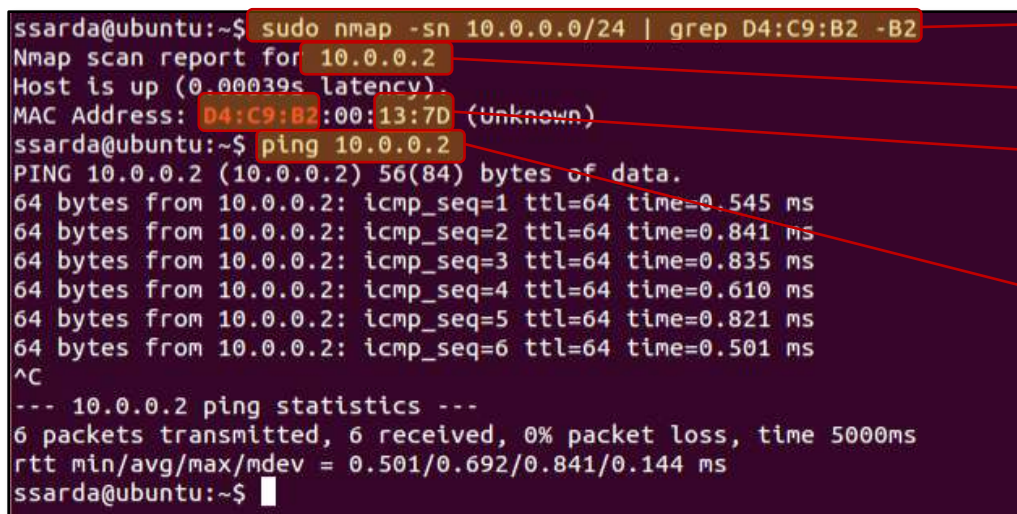
Terminal Command Reveals Serial Number and IP Address

You can also find the sensor on the network as follows:

1. Open a terminal window (Ctrl+Alt+T) and execute the following commands (after the Ubuntu \$ prompt sign), where x.x.x is the subnet the sensor is connected to.

```
$ sudo apt-get update  
$ sudo apt-get install nmap  
$ sudo nmap -sn x.x.x.0/24 | grep D4:C9:B2 -B2
```
2. The network search results (Figure 21) list the MAC address of each sensor, starting with the D4:C9:B2 sequence and ending with the last six digits of the sensor's serial number. Those digits are printed on the hardware sticker without the leading zeroes (e.g., 137D in Figure 20 and Figure 21). When you confirm that the sensor is listed, you are assured that it is properly connected to the network.
3. Look two lines above the sensor's MAC address to find the IP address of the sensor you were looking for (e.g., 10.0.0.2 in Figure 21).
4. Execute the following command to confirm that there is communication between the host computer and the sensor. (The ping command is shown with example results in Figure 21).

```
$ ping sensor_ip_address
```



```
ssarda@ubuntu:~$ sudo nmap -sn 10.0.0.0/24 | grep D4:C9:B2 -B2  
Nmap scan report for 10.0.0.2  
Host is up (0.00039s latency).  
MAC Address: D4:C9:B2:00:13:7D (Unknown)  
ssarda@ubuntu:~$ ping 10.0.0.2  
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:  
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.545 ms  
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.841 ms  
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.835 ms  
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.610 ms  
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.821 ms  
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.501 ms  
^C  
--- 10.0.0.2 ping statistics ---  
6 packets transmitted, 6 received, 0% packet loss, time 5000ms  
rtt min/avg/max/mdev = 0.501/0.692/0.841/0.144 ms  
ssarda@ubuntu:~$
```

Annotations:

- Network scan command
- Sensor IP address
- MAC sensor indicator (red), Sensor serial number abbreviation on label
- Ping command

Figure 21. Finding the Sensor IP Address from the Command Line, Pinging Sensor

5. Getting TCP Ethernet Packets

TCP Ethernet packet data is transmitted over Port 4141. Code for the current M8 sensor is Big Endian for transmitting multi-byte data in the more standard Network Byte Order.

Variable Definitions

The Ethernet packet data definitions vary depending on how the sensor is configured:

- For all three returns (as discussed in the “Multiple Returns” section, starting on page 20), refer to the variable definitions for the packet formats provided in Table 4 and Table 5.
- For a reduced number of returns (and reduced bandwidth), refer to the variable definitions for the packet formats provided in Table 6 and Table 7.

You can configure the number of returns through the Sensor Settings Management (web server) application as discussed in the “Managing the Sensor” section, specifically the “Return Data Select” subsection starting on page 48.

For All Three Returns

Table 4. Variable Definitions for M8 Packet

Field	Type	Unit/Value	Notes
PACKET HEADER			
Packet Signature	uint32	0x75bd7e97	Defines the start of a packet.
Message Size	uint32	bytes	Size of entire message (6632).
Timestamp Seconds	uint32	seconds	When used with a GPS receiver, data packages include a GPS synchronization timestamp. In the absence of a GPS receiver, the timestamp refers to a local second counter with reference to the sensor starting time.
Timestamp Nanoseconds	uint32	nanoseconds	Nanosecond part of timestamp.
API Version Major	uint8	0	
API Version Minor	uint8	1	
API Version Patch	uint8	0	
Packet Type	uint8	0x00	Value 00 is Packet Data.
PACKET DATA (See Table 5)			

Table 5. Variable Definitions for the Packet Data

Field	Type	Unit/Value	Notes
M8 Firing Data	Firing Data[50]		Array of 50 firings, see the last half of this table.
Timestamp Seconds	uint32	seconds	When used with a GPS receiver, data packages include a GPS synchronization timestamp. In the absence of a GPS receiver, the timestamp refers to a local second counter with reference to the sensor starting time.
Timestamp Nanoseconds	uint32	nanoseconds	Nanosecond part of timestamp.
API Version	uint16	5	
Status	uint16		NO_ERROR = 0 VERSIONS_MISMATCH_ERROR = (1U << 0) FIRMWARE_WATCHDOG_VIOLATION = (1U << 1)
M8 FIRING DATA			
Position	uint16	1/10400 rotation	[0, 10399] Refer to Figure 23.
Reserved	uint16		
Returns Distances	uint32[3][8]	10 micrometers	Array of distance measurements per laser (8) per return (3); 0 indicates an invalid point.
Returns Intensities	uint8[3][8]		Array of intensity measurements per laser (8) per return (3); 255 indicates saturation.
Returns Status	uint8[8]		Array of status per laser (8); always 0.

For Reduced Return

Table 6. Variable Definitions for M8 Packet

Field	Type	Unit/Value	Notes
PACKET HEADER			
Packet Signature	uint32	0x75bd7e97	Defines the start of a packet.
Message Size	uint32	bytes	Size of entire message (2224).
Timestamp Seconds	uint32	seconds	When used with a GPS receiver, data packages include a GPS synchronization timestamp. In the absence of a GPS receiver, the timestamp refers to a local second counter with reference to the sensor starting time.
Timestamp Nanoseconds	uint32	nanoseconds	Nanosecond part of timestamp.
API Version Major	uint8	0	
API Version Minor	uint8	1	
API Version Patch	uint8	0	
Packet Type	uint8	0x04	Value 04 is Packet Data.
PACKET DATA (See Table 7)			

Table 7. Variable Definitions for the Packet Data

Field	Type	Unit/Value	Notes
Status	uint16		NO_ERROR = 0 VERSIONS_MISMATCH_ERROR = (1U << 0) FIRMWARE_WATCHDOG_VIOLATION = (1U << 1)
Return ID	uint8		0, 1, or 2
Reserved	uint8	0	
M8 Firing Data	M8 Firing Data 0x04[50]		Array of 50 firings, see the last half of this table.
M8 FIRING DATA 0x04			
Position	uint16	1/10400 rotation	[0, 10399] Refer to Figure 23.
Reserved	uint16	0	
Returns Distances	uint32[8]	10 micrometers	Array of distance measurements per laser (8). 0 indicates an invalid point. This can be one of three returns as indicated by Return ID.
Returns Intensities	uint8[8]		Array of intensity measurements per laser (8). 255 indicates saturation.

Timestamp

The timestamp for each packet occurs when the last firing of the packet has been completed.

Laser Firing

The M8 sensor spins at 10 Hz (at its default and recommended setting). The lasers fire at a constant rate of exactly 53,828 Hz.

The lasers do not fire simultaneously, but in a sequence to avoid interference. The firing sequence is 0, 4, 2, 6, 1, 5, 3, 7, where 0 is the lowest downward-looking beam, and 7 is the highest upward-looking beam. There is no horizontal or vertical angle offset.

Beam Angles

The `pointcloud_generator_m8` source code specifies beam separation angles, from bottom angle to top, in radians, as follows:

```
const double M8_VERTICAL_ANGLES[] = {  
-0.318505,  
-0.2692,  
-0.218009,  
-0.165195,  
-0.111003,  
-0.0557982,  
0.f,  
0.0557982 };
```

Beam angles are shown in Figure 22.

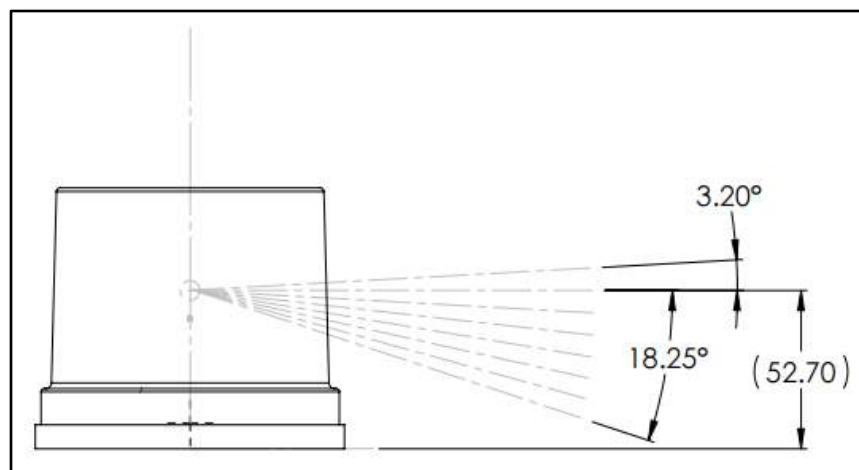


Figure 22. Laser Beam Angles

The values in the code are designed for working with optics. In round numbers, the vertical field of view is 20 degrees, the theoretical value for beam spacing is 3 degrees, and the top beam is about +3 degrees. The laser firing position is shown in Figure 23.

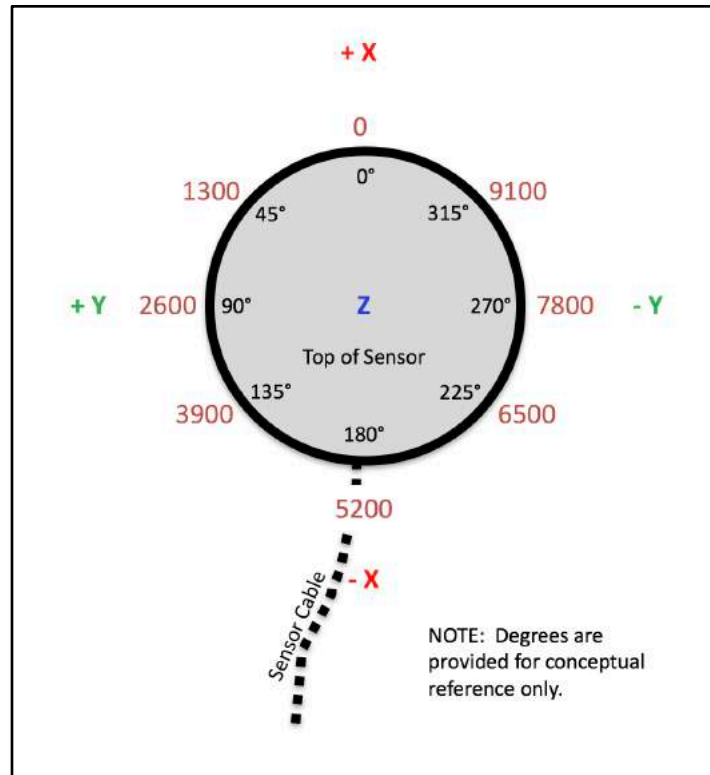


Figure 23. Laser Firing Position (Top-Down View)

6. Managing the Sensor

The M8 Sensor Settings Management application (also called the *web server* on the footer of each page) runs in a web browser to make it easy for you to edit settings for one specific sensor at a time, as identified by IP address. Although this section of the user guide reflects M8 sensor Rev D5 (the latest available version) in features, procedures, and screenshots, your web server's graphical user interface (GUI) will display only the options available for the current revision level of the particular sensor that you are managing.

Major changes by sensor version (M8 letter) and web server version (WS number) are noted in Table 8. Features are checked to indicate when they were incorporated.

Table 8. Features Introduced in Each Revision of the Sensor (M8) and Web Server (WS)

Tab/Menu	Feature	Page	M8: B WS: 1.0	C 1.1	C 1.2.5	D1-4 1.2.9	D5 ¹ 1.3.3
M8 Sensor	Log In	42	✓	✓	✓	✓	✓
	Welcome	43	✓	✓	✓	✓	✓
Settings: Edit Settings	Frame Rate	44	✓	✓	✓	✓	✓
	Scan Field	46				✓	✓
	Spinup Power	47					✓
	Return Data Select	48					✓
	Ring Settings	48			✓	✓	✓
	GPS Settings	49	✓	✓	✓	✓	✓
	Reset Settings	50	✓	✓	✓	✓	✓
Settings: Edit Network	Network Disconnect Speed	51				✓	✓
	Sensor IP Assignment	51	✓	✓	✓	✓	✓
Admin	(Not Available)	52	✓	✓	✓	✓	✓
My Account: Change Password	Change Password	53	✓	✓	✓	✓	✓
My Account: Editor Logout	Editor Logout	54	✓	✓	✓	✓	✓
Status: Basic Status	(Various)	54					✓
Versions	(Various)	56			✓	✓	✓
Reboot	Reboot	58					✓
(Troubleshoot)	Reset Static IP	59	✓	✓	✓	✓	✓
(Close the App)	Browser-Based	60	✓	✓	✓	✓	✓

¹ These features also apply to M8 Rev D4 that includes the patch updating Base firmware to 7.03. A sensor has this configuration if its Versions tab (Figure 38) reports Top Ver 6.02 and Base Ver 7.03. (This is a special exception where a major version mismatch is allowed.)

Introducing the Web Server

The navigation bar across the top of each page in the Sensor Settings Management application offers several tabs: *M8 Sensor*, *Settings*, *Admin*, *My Account*, *Status*, *Versions*, and *Reboot*, as shown in Figure 27.

Here is a summary of what users, who are called Editors, may do through the tabs:

- In the *M8 Sensor* tab, Editors can log in and view a welcome banner with important notes about getting support. (See page 42.)
- In the *Settings* tab, Editors can select from three items:
 - *Edit Settings* to adjust the frame rate, scan field, spinup power, number of returns, ring settings, and GPS settings. (See page 44.)
 - *Reset Settings* to freshly upload the default settings to the configuration file that is loaded on the sensor. (See page 50.)
 - *Edit Network* to adjust the network disconnect speed, and to set the method of IP address assignment (static versus dynamic). (See page 51.)
- In the *Admin* tab, Editors cannot select anything because this functionality is restricted to authorized support staff. (See page 52.)
- In the *My Account* tab, Editors can select from two items:
 - *Change Password* to reset the password for entering the application. (See page 53.)
 - *editor Logout* to log out of the application. (See page 54.)
- In the *Status* tab, Editors can select the *Basic Status* item, which reports the sensor's various status indicators, including fatal and non-fatal conditions. (See page 54.)
- In the *Versions* tab, Editors can view a report of each version of the software associated with the M8 sensor. (See page 56.)
- In the *Reboot* tab, Editors can choose to reboot the sensor. (See page 58.)

Editors may also reset a static IP address (page 59) and close the application (page 60).

Opening the Web Server

To access the Sensor Settings Management web server application:

1. Make sure the sensor's Ethernet sub-cable is plugged securely into the network port of the computer.
2. Know the sensor's IP address (page 31), and note it here _____.
 - If you don't know the sensor's IP address, refer to the "Reset a Static IP Address" section starting on page 59.
 - If your computer (such as Windows 7) does not supply DHCP service, make sure the sensor is configured with a static IP address. Refer to the "Reset a Static IP Address" section starting on page 59.
3. If you need to access this Sensor Settings Management application through the Ethernet port of a computer that does not have Ubuntu installed, then you must:
 - Access the computer's network settings window, such as shown in Figure 24. Create a static net mask (such as 192.168.1.0/255.255.255.0) where the IP address (e.g., 192.168.1.25) is on the same network as the gateway (such as 192.168.1.1).

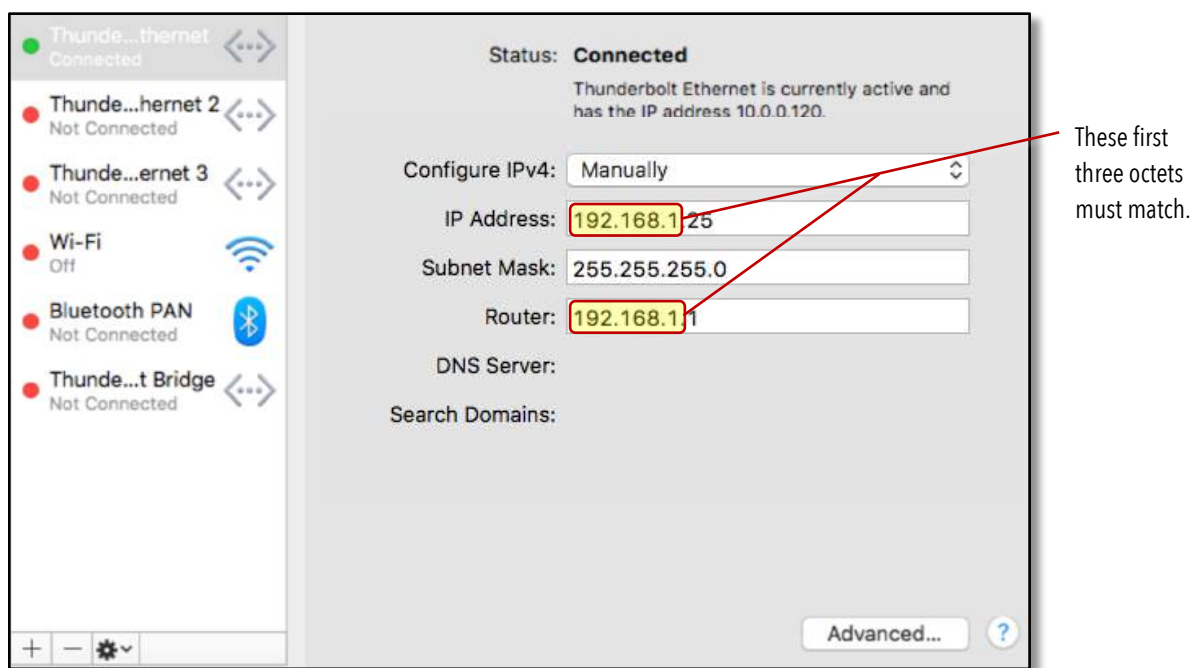


Figure 24. Creating a Network on Non-Ubuntu Machine

- If you attached the sensor to a Windows 7 host machine, refer to Figure 25, then:
 - Open the *Control Panel* item, and select the *Network and Internet* item, then the *Network Connection* item.
 - In the *Network Connections* window, select the *Local Area Connection* tab.
 - In the *Local Area Connection Properties* dialog box, select the *Networking* tab, and click the *Configure...* button.
 - In the *Internet Protocol Version 4 (TCP/IPv4) Properties* dialog box, fill in the values as follows to make sure the sensor and the Windows 7 host machine share the same local area network gateway, such as the 192.168.1:
 - Select the *Use the following IP address* radio button.
 - In the *IP address* field, type a static address for the computer, with the shared gateway (e.g., 192.168.1) and a host address that is any number from 2-254 that is available, that is, does not conflict.
 - In the *Subnet mask* field, type the subnet that both computer and sensor are on.
 - In the *Default gateway* field, after the shared gateway (e.g., 192.168.1), the last field is typically 1.
 - Select the *OK* button to apply the changes and close the dialog box.
 - In the *Local Area Connection Properties* dialog box, select the *OK* button to close the box.

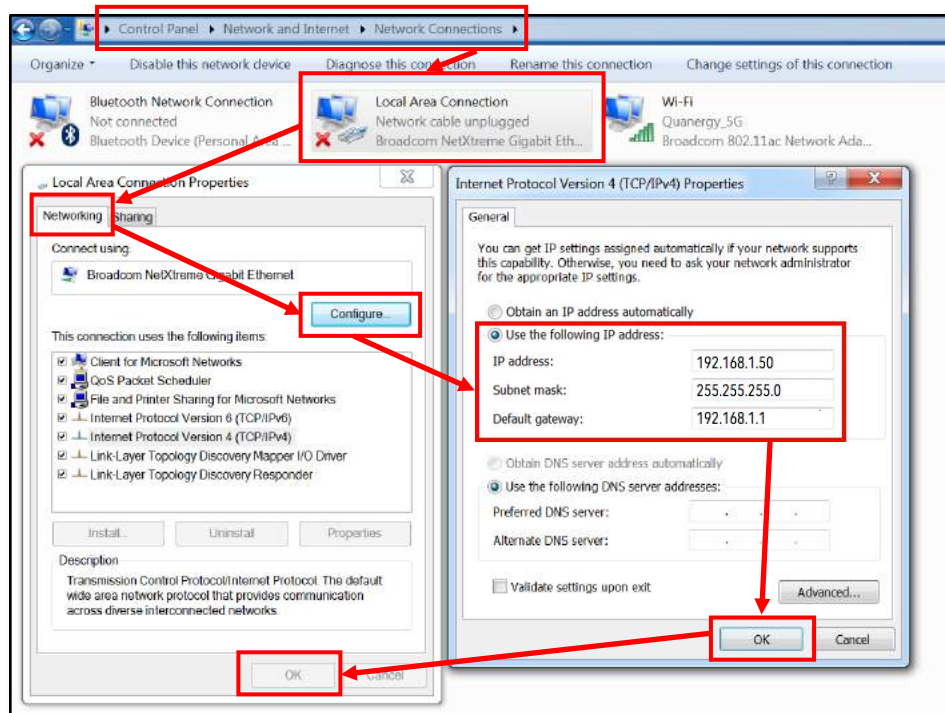


Figure 25. Creating a Network on Windows 7 Machine

4. Open a web browser such as Firefox, Chrome, or Safari.
5. In the browser's URL field, type the URL, which is simply the sensor's IP address appended by :7780 as shown in this example:

192.168.1.180:7780

6. Press the Enter key. The M8 Sensor tab appears, as shown in Figure 26.

M8 Sensor Tab

The M8 Sensor tab is the site's landing page, which appears in two modes:

- Login mode (Figure 26): allows a user to enter the site as explained below.
- Welcome mode (Figure 27): states important user notes as explained below.

Login

To log in to the application:

1. When the Login fields appear on the M8 Sensor tab as shown in Figure 26, type the case-sensitive username and password. By default, that is:

Username: editor

Password: qeditor

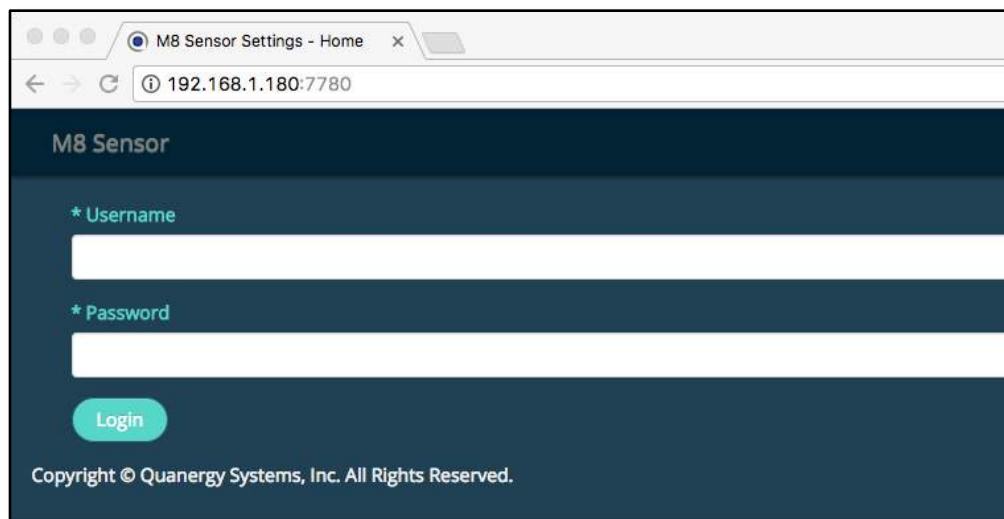


Figure 26. Web Server: M8 Sensor Tab's Login Mode

2. Press the Enter key, or click the *Login* button. Login mode disappears from the M8 Sensor tab, and the welcome mode (Figure 27) appears instead.
3. We recommend you customize your password through the Account tab (page 53).

Welcome

After the Sensor Settings Management web server accepts the login credentials, the M8 Sensor tab displays a welcome banner (Figure 27) that names the site's purpose and offers methods for getting support.

The footer provides copyright information, the application's revision number, and the sensor's complete serial number. This sensor-specific footer appears on every page except, of course, the login page.

You can return to this page at any time by clicking the M8 Sensor tab, which appears slightly enlarged in the upper left corner.

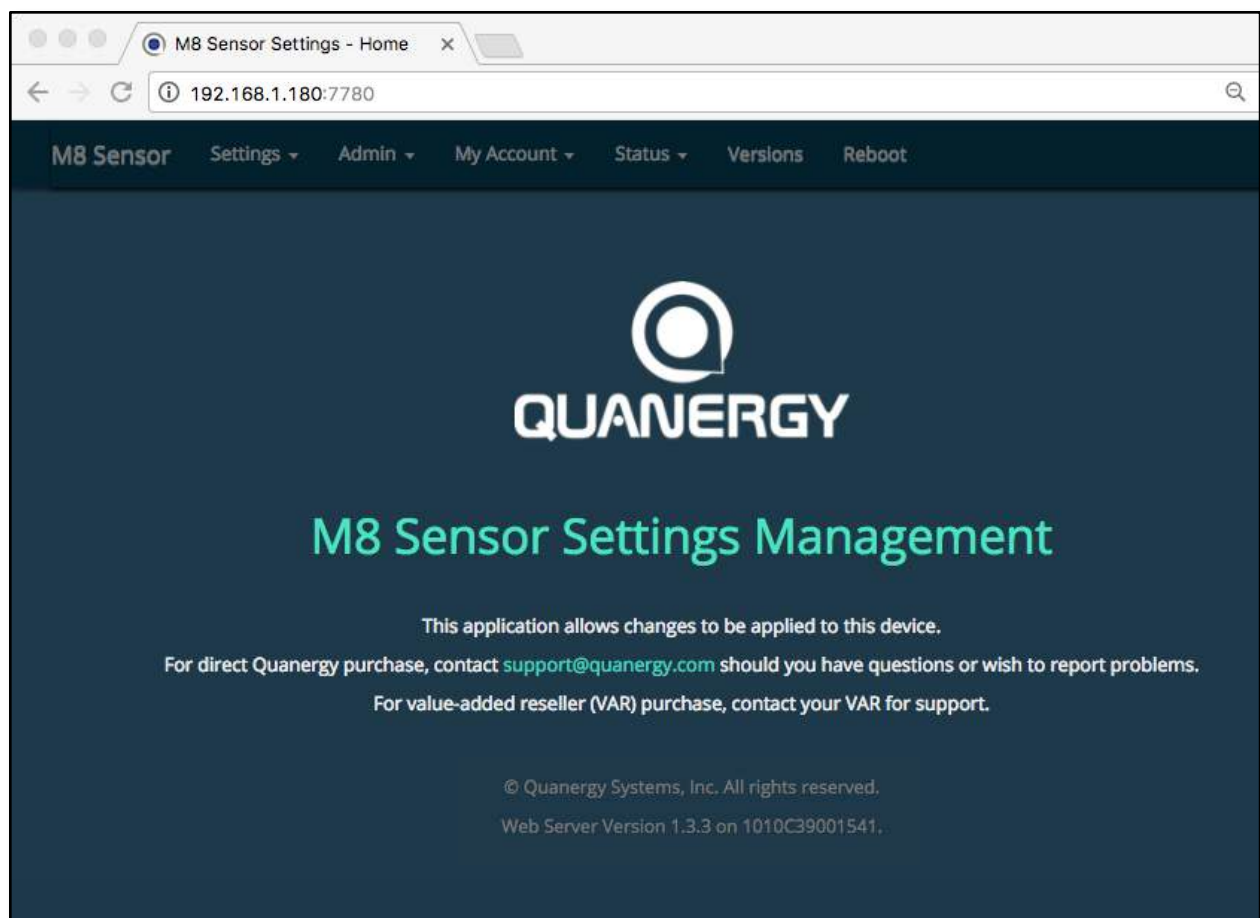


Figure 27. Web Server: M8 Sensor Tab's Welcome Mode

Settings Tab

The Settings tab offers three items (Figure 28) that provide the essential mechanisms for controlling the sensor's configuration file settings:

- *Edit Settings* — to customize various usability settings.
- *Reset Settings* — to restore to factory default settings.
- *Edit Network* — to customize network-specific settings.

This tab is explained in the following sections.

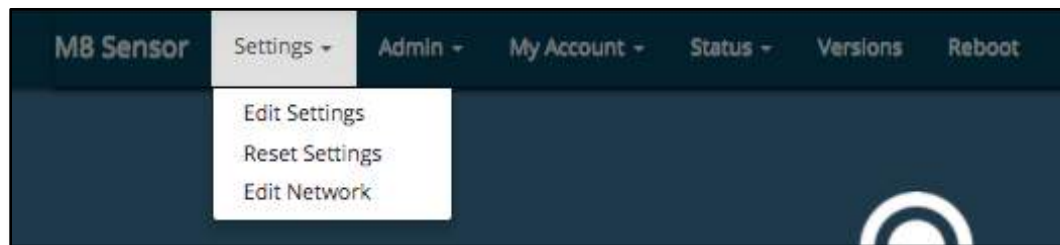


Figure 28. Web Server: Settings Tab's Menu Items

Edit Settings

Edit the sensor's settings as follows:

1. Select the Settings tab's *Edit Settings* item (Figure 28) to open the *M8 Settings Edit* page (Figure 29). This page enables the user to edit specific values in the sensor's configuration file, as discussed in the following subsections. A collapsed view of the Settings tab is shown in Figure 29 (top), which expands into sections for the *Ring settings* (right) and *GPS settings* (bottom).
2. After making as many changes as you wish to any or all of the following settings, save those changes by clicking the *Submit* button. A message confirms: "Settings updated and will be used when a new client connection is made to the sensor."

Frame Rate

The *Frame Rate in Hz* field is set at 10 hertz by default. Changing this number slows down or speeds up the sensor's rotational speed (frame rate) in cycles per second (hertz). To change the frame rate (Figure 29 top):

1. In this field, you can type a whole number from 5 to 20, but Quanergy recommends 10 Hz for most applications.
2. Click the *Submit* button, or continue making changes in the next section.

M8 Sensor
Settings
Admin
My Account
Status
Versions
Reboot

M8 Settings Edit

Change settings to desired values and press submit.

* Frame Rate In Hz

* Scan Field Center Angle

* Scan Field Width In Degrees

* Low Power Spinup

☐
 Uncheck for normal power spinup. Check for low power spinup.

* Return Data Select

All 3

Ring settings

GPS settings

Submit

Cancel

Ring settings

* Ring Range 0 In cm

* Ring Intensity 0

* Ring Range 1 In cm

* Ring Intensity 1

* Ring Range 2 In cm

* Ring Intensity 2

* Ring Range 3 In cm

* Ring Intensity 3

* Ring Range 4 In cm

* Ring Intensity 4

* Ring Range 5 In cm

* Ring Intensity 5

* Ring Range 6 In cm

* Ring Intensity 6

* Ring Range 7 In cm

* Ring Intensity 7

GPS settings

* PPS Signal (Pulse per Second) from GPS

☐
 Uncheck for positive (non-inverted) signal. Check for negative (Inverted) signal.

* Serial Signal from GPS

☐
 Uncheck for active high signal. Check for active low signal.

* NMEA Baud Rate

4800

Figure 29. Web Server: Settings Tab's M8 Settings Edit (top), Rings (right), GPS (bottom)

Scan Field

Scan Field parameters apply to sensors of Rev D1 and up. These parameters are useful if you need to restrict the amount of data being transmitted by the sensor to save bandwidth. The settings (Figure 29 top) activate a scan of the entire field of view to collect all the data that is possible. You can customize the values, as follows:

1. In the *Scan Field Center Angle*, type the number of degrees from 0.0 to 360.0. The value of 0.0 is along the +X axis and away from the sensor cable.
2. In the *Scan Field Width in Degrees*, type the number of degrees from 0.0 to 360.0. The value of 360.0 encompasses the entire field of view.
3. Click the *Submit* button, or continue making changes in the next section.

Three real-world scenarios, including a car roof-mounted sensor, a wall-mounted sensor, and a drone-mounted sensor, are shown in Figure 30 and discussed below. Settings that would appropriately address them are listed and shown in Table 9.



Figure 30. Usage-Based Sensor Placement Improves Results

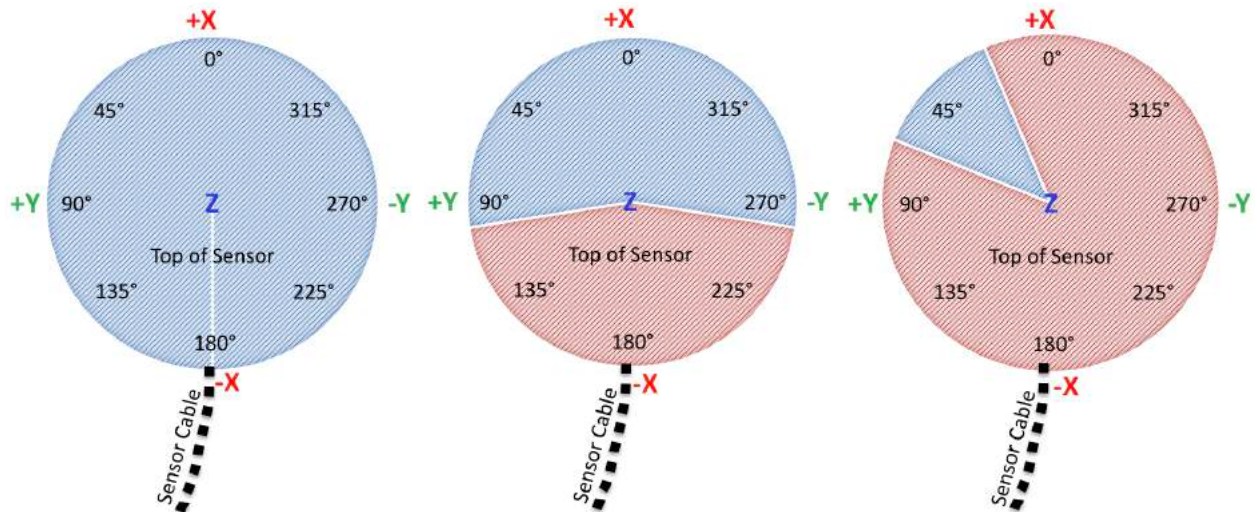
A sensor mounted on the roof of a car represents a typical automotive situation, where the sensor may need to scan for movement all around the car. Even the rear view is important for parking and attending to speeders who could collide with the back bumper. Therefore, the *Scan Field Width in Degrees* parameter is set at 360.0° to include the entire field of view, that is, to scan a full circle around the Z axis. The *Scan Field Center Angle* parameter tells the sensor where to center the field of view to focus straight ahead as the car drives forward, at the 0.0° point.

A sensor mounted to a wall for security purposes only needs to scan for a 200.0° field of view, centered at the 0.0 point (straight out from the wall) since the wall is inactive.

A sensor mounted on a drone does not need to scan the entire field of view since the sky is not important. And if the purpose is to map only the left side of a road from an offset, a 45.0° field of view centered at 45.0° may be sufficient and conserve precious bandwidth.

Table 9. Web Server: Scan Field Specifications Based on Sensor Placement

Mounted on Car Roof	Mounted to Wall	Mounted on Drone
Scan Field Width in Degrees:		
360.0	200.0	45.0
Scan Field Center Angle:		
0.0	0.0	45.0
Scan Field is the Blue Area When Looking Down on the Sensor:		



Low Power Spinup

The *Low Power Spinup* parameter applies to M8 Rev D5 and up, as well as to M8 Rev D4 with patch updating Base firmware to 7.03. When enabled, this option uses less torque during startup and delays turning on the lasers until the turret has reached the desired speed, saving about 2 watts from the peak startup power. As a consequence, when compared to normal startup, the point cloud's appearance may be delayed by as much as an additional 15 seconds.

The *Low Power Spinup* field is unchecked by default, as shown in Figure 29 (top).

1. Check this box if you prefer to save power during spinup.
2. Click the *Submit* button, or continue making changes in the next section.

Return Data Select

The *Return Data Select* parameter applies to M8 Rev D5 and up, as well as to M8 Rev D4 with patch updating Base firmware to 7.03. If you have bandwidth constraints and don't need all three of the returns, the *Return Data Select* dropdown menu allows you to specify which of the returns to report. Refer to the discussion and definition of these returns on page 20.

The options are: *Return 0*, *Return 1*, *Return 2*, and *All 3* (default), as shown in Figure 29 (top).

1. Select the preferred value from the menu.
2. Click the *Submit* button, or continue making changes in the next section.

Depending on your selection, the TCP Ethernet data packet changes as discussed in the "Getting TCP Ethernet Packets" section starting on page 33.

Ring Settings

The *Ring Settings* parameters apply to sensors of Rev C and up. The *Ring Range X in cm* and the *Ring Intensity X* fields are a pair of settings that work together to filter out the points that are:

- Up to a specified *Range* (radial distance in cm) from the sensor's Origin, which is the sensor's internal intersection of X, Y, and Z axes (0,0,0).
- Up to a specified *Intensity* value, that is, reflectivity (0-255) of an object, which is visualized as a color.
- Originally emitted by *X*, which represents one of the eight stacked laser beams in the M8 sensor. In particular, 0 is for the bottom downward-looking beam, numbering up through 7 for the top upward-looking beam.

If you ever see artifact points showing up as a ring in the point cloud, you may refer to Figure 29 (top, right) and adjust the filter for one or more laser beams (0-7), as follows:

1. Select the *Ring Settings* button text to expand that section of the *M8 Settings Edit* page.
2. In the *Ring Range X in cm* field, type a number for the distance from the Origin up to which the points may be filtered out.
3. In the *Ring Intensity X* field, type a number (0-255) representing the reflectivity and visualized color of an object to filter out. 0 filters out no points/colors; 255 filters out all points/colors. The optimal setting is therefore a very low number. For example, with a setting of 4, all points of *Ring Intensity X* up to 4, within the set *Ring Range X* distance, are filtered out.
4. Select the *Ring Settings* button text to collapse that section of the *M8 Settings Edit* page.
5. Click the *Submit* button, or continue making changes in the next section.

GPS Settings

Users who employ a GPS/IMU receiver can take advantage of its signal output. If the sensor is not receiving a GPS signal, these three settings have no effect.

Refer to Figure 29 (top and bottom) and make sure the GPS signals are set according to your equipment and preferences, as follows:

1. Select the *GPS Settings* button text to expand that section of the *M8 Settings Edit* page.
2. The *PPS Signal (Pulse per Second) from GPS* checkbox is for setting the sensor to accept a positive (non-inverted) or negative (inverted) PPS signal from a GPS receiver, as explained in Appendix 1, starting on page 66. If the sensor is receiving a PPS signal:
 - Uncheck the box to accept PPS signal as is: high stays high, low stays low.
 - Check the box to invert the PPS signal: changes high input to low, low to high.
3. The *Serial Signal from GPS* check box is for setting the sensor to accept the NMEA sentence as a serial signal from the GPS device:
 - Uncheck the box to accept the signal as active high (non-inverted).
 - Check the box to invert the signal to be active low (inverted).
4. The *NMEA Baud Rate* drop-down menu is for syncing with the GPS serial data rate. Consult the GPS device documentation to know which rate to select. This menu lists a range of baud rate options from 1200-2000000. 4800 is the default rate.
5. Select the *GPS Settings* button text to collapse that section of the *M8 Settings Edit* page.
6. Click the *Submit* button, or continue making changes in the next section.

Reset Settings

The Settings tab's *Reset Settings* item allows Editors to restore to factory defaults all changes that were previously made to the sensor's configuration file, as follows:

1. Select the Settings tab's *Reset Settings* item to open the *M8 Settings Reset* page (Figure 31).
2. A confirmation message immediately appears in the Settings tab: "Sensor settings will be reset to factory defaults. Continue?" (Figure 31 left).

NOTE: As of M8 sensor Rev D5 and up, restoring factory settings means that the IP address will receive its original static IP assignment of 192.168.1.3.

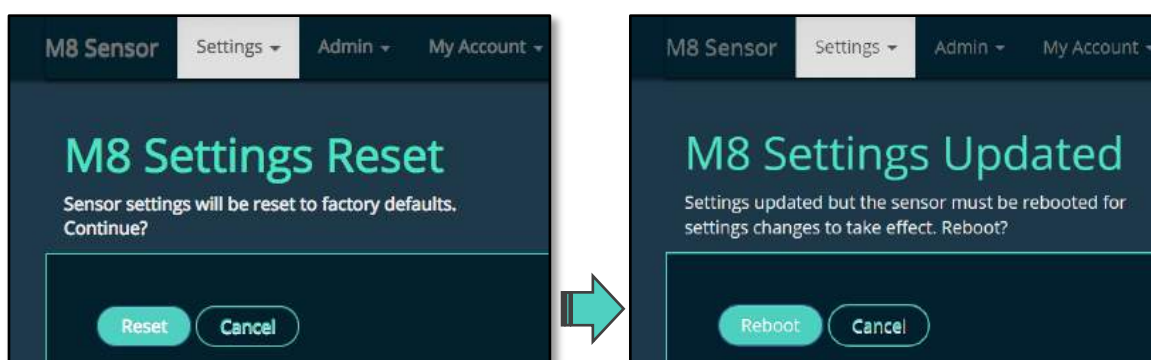


Figure 31. Web Server: Settings Tab's Reset Message (left), Reboot Message (right)

3. If you select the *Reset* button, the settings are uploaded, and a Reboot confirmation page appears (Figure 31 right). (Settings are only applied if the sensor is rebooted.)
4. If you wish to reboot and apply the settings, then click the *Reboot* button. The sensor reboots and the browser redirects to the M8 Sensor home page (Figure 27). Because the sensor may take 40 seconds to reboot, the home page may not be useable until the sensor is back online.

Edit Network

The Settings tab's *Edit Network* item allows Editors to customize these network settings:

- *Network Disconnect Speed*: How *Fast* or *Slow* the sensor will react if it is suddenly and unexpectedly disconnected from power. This parameter applies to sensors of Rev D1 and up.
- *Sensor Network Settings Configuration*: How the sensor is assigned an IP address, whether:
 - *Dynamic*: Automatically assigned by a DHCP server. With this method, the IP address may change if the user power cycles the sensor or moves it to a different network, but you can always rediscover it, as explained in the “Find the Serial Number and IP Address” on page 31.
 - *Static*: Manually assigned by a user. With this method, the IP address remains stable and unchanged, but if you forget it, you will need to re-address the sensor, as explained in the “Reset a Static IP Address” section on page 59.

Configure these sensor settings according to your preferences, as follows:

1. Select the Settings tab's *Edit Network* item to open the *M8 Network Settings Edit* page (Figure 32).
2. Click the drop-down menu under the *Network Disconnect Speed* heading, and select one of the following options:
 - *Fast* — causes the spinning to stop completely within 8 seconds (default value).
 - *Slow* — causes the spinning to stop completely within 48 seconds.
3. Click one of the following radio buttons to change the method of assignment:
 - *Dynamic* — sensor accepts IP address assignment from DHCP server (default value).
 - *Static* — sensor accepts IP address assignment by a human user.
4. Click the *Submit* button. If the *Sensor Network Settings Configuration* selection...
 - ...remained *Dynamic* or changed to *Dynamic*, a message confirms, “Network settings updated but the sensor must be rebooted for changes to take effect. Reboot?”
 - ...remained *Static* or changed to *Static*, the web server displays fields where you can update or populate values within the network range. Figure 32 (bottom) displays example values that are probably different from those on your actual network.
 - For future reference and for the log-in URL, note the new IP address on page 40.
 - Select the *Submit* button to save the changed IP settings. “Network settings updated but the sensor must be rebooted for changes to take effect. Reboot?”
5. Click the *Reboot* (or *Cancel*) button as shown in Figure 32 (top right). The sensor reboots and the browser redirects to the M8 Sensor home page (Figure 27). Because the sensor may take 40 seconds to reboot, the home page may not be useable until the sensor is back online.

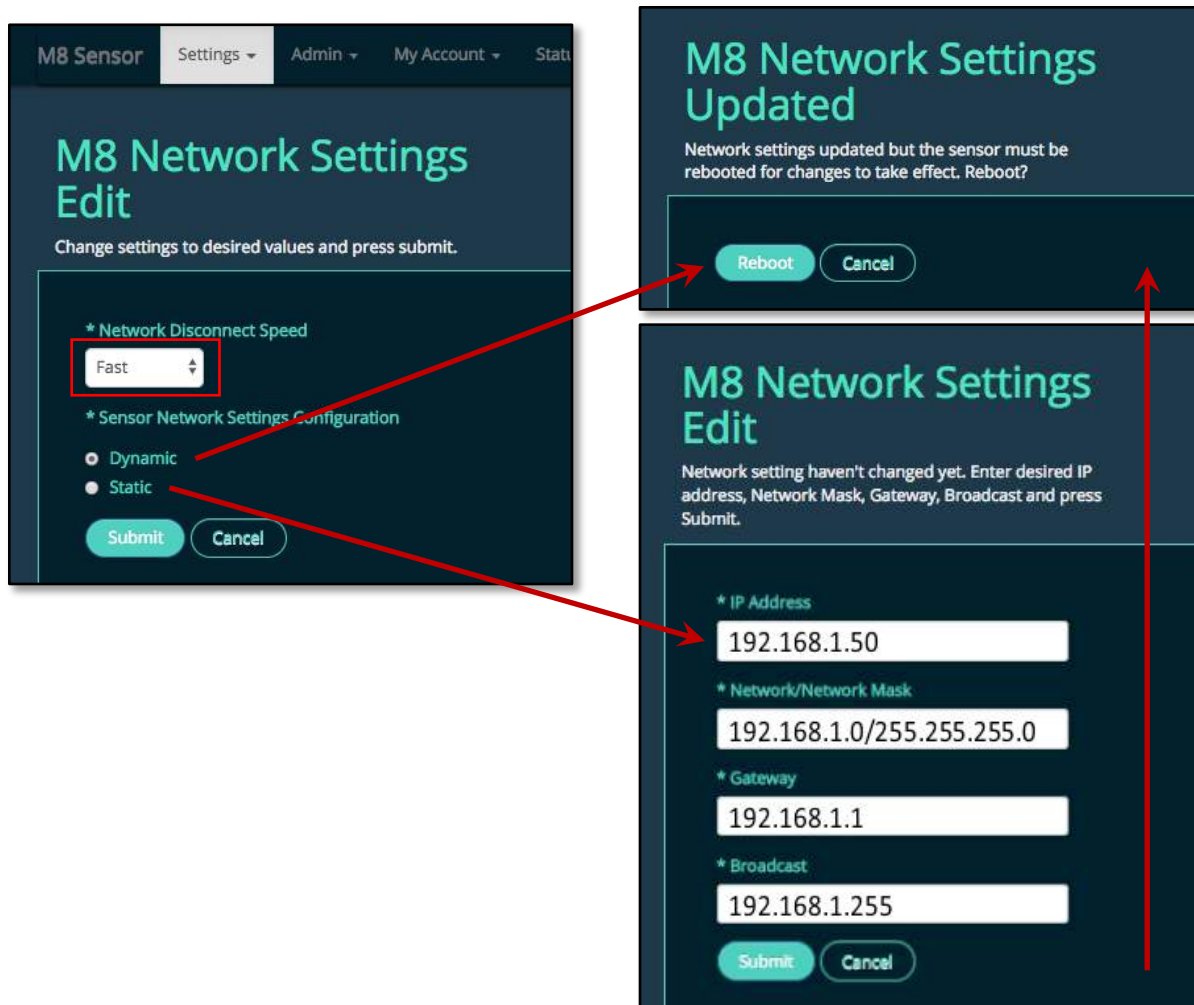


Figure 32. Web Server: Settings Tab's Network Settings (left), Static IP (bottom), Reboot (top)

Admin Tab

The Admin tab (Figure 33) is not available to Editors, so selecting this tab does not offer any selectable items.

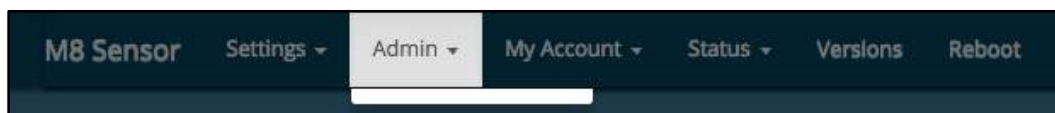


Figure 33. Web Server: Admin Tab

My Account Tab

The My Account tab offers two items: *Change Password* and *editor Logout* (Figure 35).

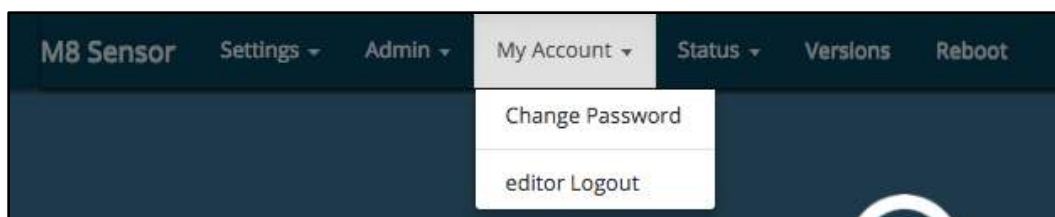


Figure 34. Web Server: My Account Tab's Change Password and editor Logout Items

Change Password

We recommend that you customize your password. To change the Editor's password:

1. Select the *Change Password* item from the My Account tab.
2. In the fields that appear (Figure 35), type the old password once and the new password twice.
3. Select the *Save* button.
 - If the process was successful, the M8 Sensor tab opens with this notification: "Your password has been changed."
 - If the process was not successful, the My Account tab displays a message: "There was a problem with your submission. Errors have been highlighted below." Try again or select the *Cancel* button, which opens the M8 Sensor tab).
4. IMPORTANT: Also save the new password in a secure location because there is no password recovery process in this application. If you forget your password, contact your support representative.
5. To apply the change, follow the Reboot tab procedure on page 58.

A screenshot of the 'Change Password' form. It features three input fields: 'Old Password', 'New Password', and 'Retype Password'. Each field is preceded by a red asterisk indicating it is required. At the bottom of the form are two buttons: a green 'Save' button and a grey 'Cancel' button.

Figure 35. Web Server: My Account Tab's Change Passwords Fields

editor Logout

When you are ready to log out:

1. Select the *editor Logout* item (Figure 34) from the My Account tab. The changes you made and submitted through the Settings tab will be used the next time a connection to the sensor occurs.
2. You are returned to the M8 Sensor tab in Login mode (Figure 26), where you can log back in.

Status Tab

The Status tab applies to M8 Rev D5 and up, as well as to M8 Rev D4 with patch updating Base firmware to 7.03. This tab offers one item: *Basic Status* (Figure 36).

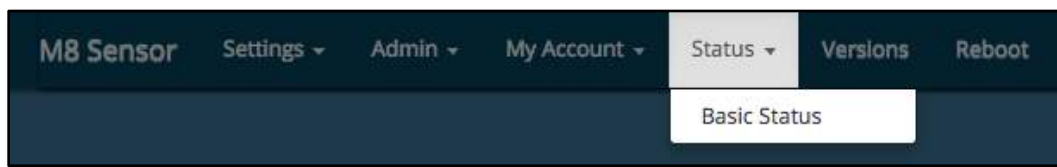


Figure 36. Web Server: M8 Status Tab

The Status tab reports the sensor's status for the *GPS Lock*, *Frame Rate*, *Sensor Temperature*, *Watchdog Status*, *Motor Initialization Failure*, *Insufficient Motor Velocity Failure*, *Version Mismatch Error*, *Laser Overtemp Error*, *CPU Overtemp Error*, *Seconds*, and *Nanoseconds*. It reveals a snapshot of truth at the time the page loaded.

- To view the report, click the Status tab. The sensor needs to have been running for a period of time in order to generate meaningful statistics. The web server may pause briefly to gather the very latest information before displaying a list of statuses. See an example of the report in Figure 37. Refer to Table 11 for an explanation of each status that is listed.
- To refresh the report, select *Basic Status* again from the Status tab menu or use your browser's page reload mechanism. An updated report will appear.

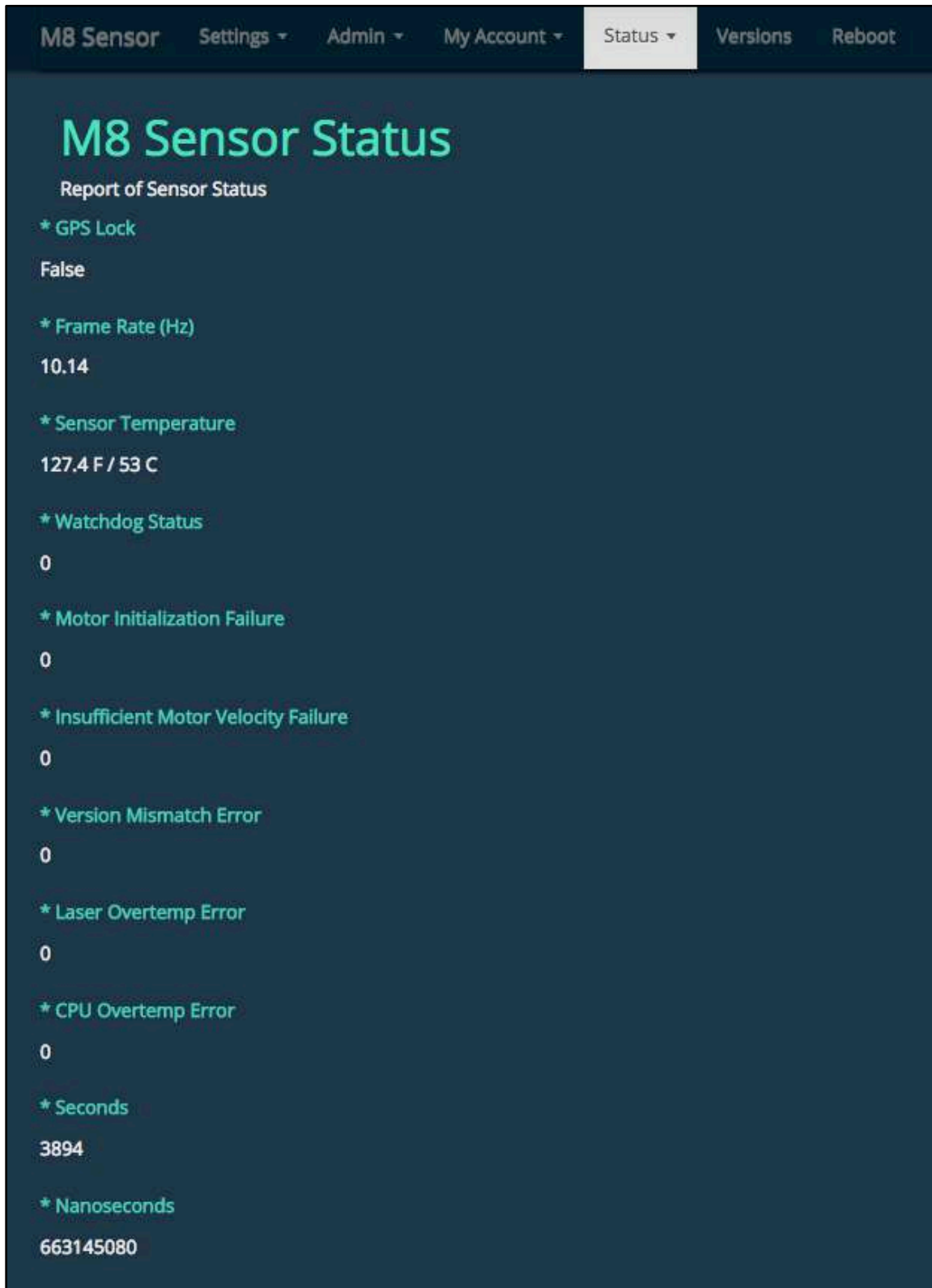


Figure 37. Web Server: M8 Sensor Status Tab's Report

Versions Tab

The Versions tab applies to sensors of Rev C and up. This tab is a simple report of each version of the software associated with the M8 sensor.

To view the report, click the Versions tab. The web server may pause briefly to gather the very latest information before displaying a list of software items found. See an example of the report in Figure 38. Notice that the "Report of Sensor..." heading states the sensor's general revision number. Refer to Table 13 for an explanation of each version that is listed.



Figure 38. Web Server: Versions Tab's Report of Associated Software

Table 10. Web Server: M8 Software Version Definitions

Version	Refers To
Top Ver	Firmware programmed into the FPGA on the turret (top)
Base Ver	Firmware stated on the base (bottom) of the unit, consisting of the next several items
Linux	Release version of the Linux Operating System (OS) that runs on the Advanced RISC Machine (ARM) core in the processing chip
Linux Driver	Shared library of privileged, memory resident, low level hardware handling routines
PS Code	Embedded Programmable Software (PS) that runs in the Linux OS
PL Code	Firmware (Programmable Logic) in the processing chip's field-programmable gate array (FPGA)
BIST Code	Script that enables the Built-In System Test
Web Server Code	Scripts that generate the web interface pages
Scripts	Scripts for installation and setup

Reboot Tab

The Reboot tab offers a software reboot option. It applies to M8 Rev D5 and up, as well as to M8 Rev D4 with patch updating Base firmware to 7.03.

This is as an alternative to the equivalent physical method of unplugging the sensor's power cord from the power *source*, waiting 2 seconds, plugging in the power cord, and waiting another 40 seconds before proceeding. Earlier generation sensors still need to reboot in this manual way to apply and save any changes that were made through the Sensor Settings Management web server interface.

NOTE: *Never* unplug the cord at the M8 sensor's ferrule power connector (Figure 14 right) or toggle a connected power strip's on/off switch because the current still latent in the cord can shock the sensor. *Instead*, unplug the sensor at the power source (wall outlet or power strip, for example) or at the M19 connector (Figure 14 left) or via the Reboot tab.

To reboot the sensor remotely, click the Reboot tab. A confirmation page appears as shown in Figure 39.

- If you select the *Reboot* button, the sensor reboots and the browser redirects to the M8 Sensor home page (Figure 27). Because the sensor may take 40 seconds to reboot, the home page may not be useable until the sensor is back online.
- If you select the *Cancel* button to abort the reboot, the browser redirects to the M8 Sensor home page (Figure 27).

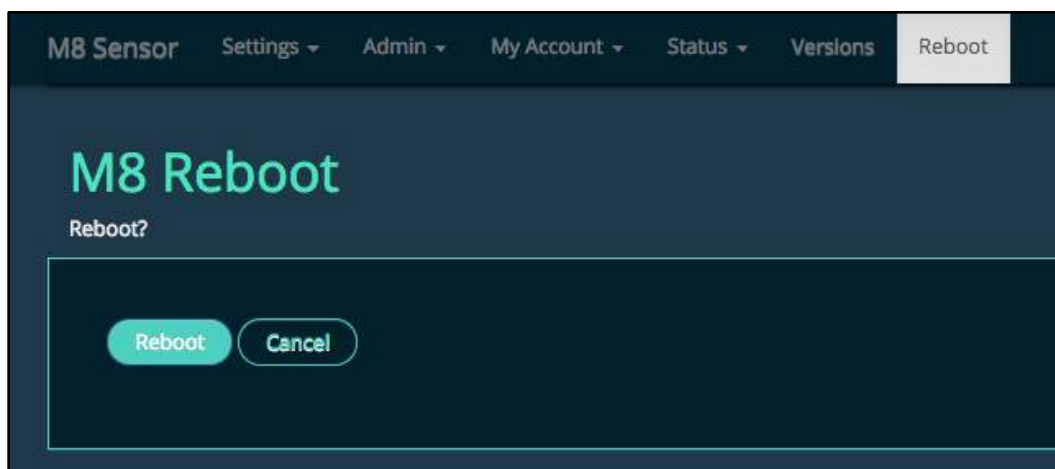


Figure 39. Web Server: Reboot Tab's Confirmation Page

Reset a Static IP Address

A special *fail safe mode* allows you to reset the IP address and subnet of a sensor in the following circumstances:

- The sensor was previously assigned a *STATIC* IP address (page 51).
- The sensor's *STATIC* IP address is currently unknown.
- The sensor's subnet is currently unknown.

NOTE: Fail safe mode works only for a sensor that has had a static IP address assigned to it manually. It does *not* work if the sensor's IP address was assigned dynamically via DHCP server.

Reset the sensor's IP address through the fail safe mode, as follows:

1. Make sure the sensor is plugged directly into a computer (any platform) that allows you to create your own network.
2. Open that computer's network settings window, such as the example shown in Figure 40, and assign the following:²
 - *IP Address* field: 192.168.1.x, where x is any number 7-254 that does not conflict
 - *Subnet Mask* field: 255.255.255.0
 - *Router* field: 192.168.1.1

The IP address is therefore on the same network as the router/gateway, and the first three octets of each are 192.168.1.

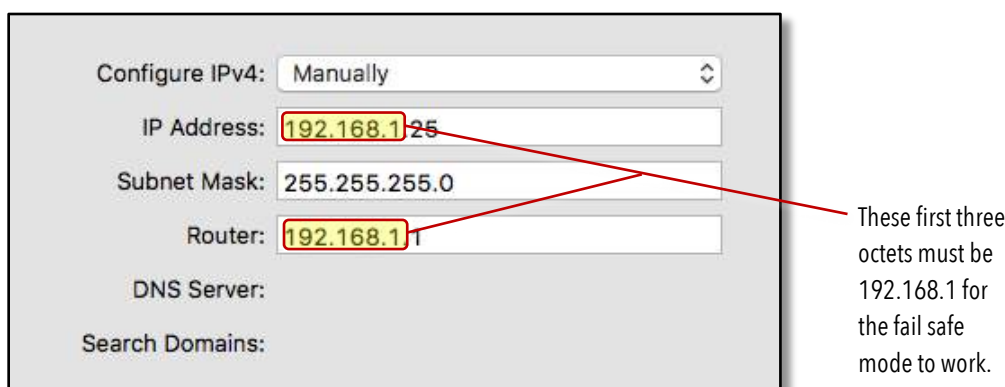


Figure 40. Creating a Network Environment for Fail Safe Mode

² For M8 Rev D1 and below, the fail safe IP address is 10.1.10.200, so in Steps 2 & 7 above, use subnet 10.1.10 instead of 192.168.1.

3. Unplug the sensor sub-cables from the power supply and from the network port, and wait 2 seconds. (It's fine to remain attached to a GPS/IMU receiver if you have one.)
4. Reattach the sub-cable only to the power supply, and immediately start a timer.
5. Wait until the 2:45 minute mark (2 minutes and 45 seconds), when the fail safe mode becomes enabled, allowing you 60 seconds to accomplish the next step.

NOTE: Wait time varies depending on the revision of the sensor:
Rev B: At 3:00 minute mark, an unlimited window starts.
Rev C: At 4:55 minute mark, a 10 second window starts.
Rev D: At 2:45 minute mark, a 60 second window starts.

6. Reattach the Ethernet sub-cable to the network port. (No additional wait time is necessary.)
7. In the browser's URL field, type the fail safe mode URL:

192.168.1.3:7780
8. Log in with the usual case-sensitive username (`editor`) and password (which is `qeditor` unless you updated it), as discussed on pages 42 and 53.
9. Once you have logged in, you will need to update the sensor to a new static IP address or change it back to a dynamically assigned IP address, as explained in the "Edit Settings" section starting on page 44. (If you assign the sensor a new static IP address, note it on page 40.)
10. Return your computer's network settings window to its previous configuration.

Closing the Web Server

After logging out as discussed on page 54, close the Sensor Settings Management web server application's tab or window through mechanisms provided in your particular browser.

7. Taking the Next Steps

Depending on which computing environment the M8 sensor has integrated into, the specific instructions vary for how to work with the sensor to accomplish data collection, visualization, and calibration. Refer to the user guide related to your particular computing environment for the next steps:

- *Q-View User Guide* - <https://quanergy.desk.com/customer/portal/articles/2717074>
- *Sensor SDK User Guide for Ubuntu* - <https://quanergy.desk.com/customer/portal/articles/2688864>
- *Sensor SDK User Guide for Windows* - <https://quanergy.desk.com/customer/portal/articles/2688870>

8. Stopping the Sensor

Any program that is using the sensor is maintaining a TCP connection.

Shut Down

To shut down the sensor:

1. Terminate whichever program is communicating with the sensor. The sensor may stop spinning.
2. If the sensor does not stop spinning, simply disconnect it from the power source to stop its activity.

Restart

To restart the sensor:

1. Disconnect the sensor from the power source (if it's not already disconnected).
2. Reconnect it to the power source.

9. Troubleshooting Issues

The M8 sensor is designed for excellent reliability and longevity. However, if the sensor is prevented from integrating, connecting, spinning up, firing, or collecting data, your support representative is committed to fully support you in resolving it.

- For purchases made directly from Quanergy, contact support@quanergy.com.
- For purchases made from a third party such as a value-added reseller or system integrator, contact them for support.

Check the Status

If you suspect your sensor may have an issue, check the sensor's health through the web server's Status tab (page 54) or Q-View diagnostics panel (discussed in the *Q-View User Guide* at <https://quanergy.desk.com/customer/portal/articles/2717074>). Statuses and error codes are explained in Table 11.

Table 11. Web Server: M8 Software Status Definitions

Status	Value	Meaning
GPS Lock	True (locked)	Indicates that all of the following criteria are met: • Sensor is attached to the NMEA/PPS inputs. • PPS pulse width is at least 10 milliseconds.³ • Internal clock is successfully trained to the GPS external reference input (satellite). • Internal timebase is properly adjusted to GPS time so that the PPS input always arrives within 4 μs of the internally expected time.
	False (unlocked)	Indicates that any or all of the above criteria have not been met.
	NOTE:	As the system is adapting the sensor's internal timebase to the GPS reference, it will likely see the PPS indication at the wrong expected time and declare the system "unlocked." If the sensor is operated prior to attaining a GPS lock, GPS timestamps embedded in the point cloud data stream may jump by large increments.
Frame Rate (Hz)	Numerical value	Reports the sensor's precise rotational speed in hertz.
Sensor Temperature	Numerical value	Reports the sensor's precise internal temperature in Fahrenheit and Celsius.

³ 10 milliseconds is long enough to maintain a valid pulse while filtering out spikes on the PPS line. If necessary, adjust the pulse width on the GPS receiver using the manufacturer's online tool.

Status	Value	Meaning
Watchdog Status	0	Indicates normal operation.
	1	Indicates fatal error. The system detected an internal fault and to safeguard the sensor it shut down the motor (and the lasers).
	ACTION:	This rare condition typically occurs in highly congested network connections. Disconnect/reconnect to clear the error and restart the sensor. If condition persists, fix the congestion on the network.
Motor Initialization Failure	0	Indicates normal operation.
	1	Indicates non-fatal error. The motor is unable to start within 15 seconds of connecting to the sensor.
	ACTION:	Disconnect/reconnect to clear the error. If error persists after multiple reconnections, contact your support representative.
Insufficient Motor Velocity Failure	0	Indicates normal operation.
	1	Indicates non-fatal error. After the initial 90-second startup period, the motor velocity is below 80% of its target speed.
	ACTION:	Disconnect/reconnect to clear the error. If error persists after multiple reconnections, contact your support representative.
Version Mismatch (Code 0x01 in Q-View diagnostics panel)	0	Indicates normal condition.
	1	Indicates error condition.
	ACTION:	Contact your support representative.
Laser Overtemp Error (Code 0x08 in Q-View diagnostics panel)	0	Indicates normal condition.
	1	Indicates non-fatal error. Temperature of laser and/or detector exceeded the maximum threshold.
	ACTION:	Cool the sensor by disconnecting from its power source. Mount the sensor to its detachable base plate (400 g aluminum) or to a heat sink of similar or greater thermal mass to prevent overheating, then reconnect to power.
CPU Overtemp Error (Code 0x10 in Q-View diagnostics panel)	0	Indicates conditions are normal.
	1	Indicates non-fatal error. CPU (base) temperature exceeded maximum threshold.
	ACTION:	Cool the sensor by disconnecting from its power source. Mount the sensor to its detachable base plate (400 g aluminum) or to a heat sink of similar or greater thermal mass to prevent overheating, then reconnect to power.
Seconds	Numerical value	This rolling counter increments as follows: • If an external GPS is connected, seconds displays time since epoch (GPS time). • If an external GPS is not connected, seconds starts counting up from 0 each time the sensor reconnects.
Nanoseconds	Numerical value	This rolling counter increments up from 0. After it reaches 999999999, it increments the Seconds counter, resets its own counter to 0, and starts over.

Perform Cleaning

If cleaning of the M8 sensor lens cap is necessary:

- Lightly dampen a clean, lint-free, cloth or tissue with alcohol or distilled water.
- Wipe the sensor in one direction. (If using alcohol, avoid wiping the labels, since it may smear the ink.)
- Dry the sensor with another lint-free cloth or tissue.

Resolve an Issue

Most issues that might be encountered with the M8 sensor can be resolved by using one or more of these strategies:

- Make sure the sensor has an adequate heat sink, as explained on page 22.
- Unplug the sensor's sub-cable from the power source, wait 10 seconds to reload the sensor settings, and plug back in.
- Leave the sensor completely shut off for several hours of unpowered downtime.

Check an Issue

Tools and indicators can be helpful to assess a situation:

- The sensor's AC/DC power adapter must have a **power indicator** to help you know if there is a problem with the power source. When the power is on, the power indicator (such as the LED shown in Figure 3 and Figure 41) should glow steadily. If it is blinking or off, there may be a power problem.



Figure 41. Power Indicator on the AC/DC Power Adapter

- The unaided eye cannot directly detect that a laser is actually firing. However, an eye viewing the laser through an **infrared (IR) scope** can look into the sensor from the side and notice rapid, rhythmic laser flashes, which confirm that the laser is firing.



Figure 42. View Sensor through IR Scope (left) to See Sensor Flash+Reflection (right)

- The Q-View Sensor Management and Visualization software **Dashboard tab** lets you check a sensor's health and any error codes that might pop up. (Refer to the "View the Sensor Diagnostics" section in the *Q-View User Guide*, downloadable from <https://quanergy.desk.com/customer/portal/articles/2717074>.)
- The M8 Sensor Settings Management application's **Versions tab** reports versions of the software associated with the M8 sensor, as discussed on page 56.

Report an Issue

If problems persist with sensor operation after trying the previous strategies, contact your support representative and provide a description of what you've observed, what you've done to resolve the issue, and the affected sensor's revision and serial number.

If you observe an issue, or an error message appears in the terminal window, capture it in a screenshot or text file, describe what action prompted the error, and email it along with the sensor's revision and serial number to your support representative.

Appendix 1: Use of NMEA/PPS Signals

This appendix is provided for users who need accurate, reliable timestamps on each data point collected by the M8 system.

For the M8 system to enable the added value of a Coordinated Universal Time (UTC) timestamp, two inputs are required, and Global Positioning System (GPS) units typically provide them:

- National Marine Electronics Association (NMEA) message, called a *sentence*
- Pulse-per-second (PPS) signal

NOTE: Quanergy has not tested all GPS/IMU modules for all situations, but supports the OXTS RT3003 and VectorNav200 GPS receivers. The Garmin GPS18x has also tested well in outdoor conditions.

Concepts and Specifications

This section describes the purpose, definitions, and specifications related to the use of the NMEA sentence and the PPS signal.

Purpose of NMEA

NMEA 0183 is an electrical and data specification for communication between GPS receivers and instruments such as the M8 LiDAR sensor. This standard is controlled by the National Marine Electronics Association.⁴

When you need to know the precise time that a data point was recorded, such as for creating a composite map, the NMEA sentence along with one PPS signal provides absolute timestamping according to the Coordinated Universal Time (UTC) standard, accurate up to five microseconds.

⁴ For more details, refer to <http://www.actisense.com/wp-content/uploads/2017/07/NMEA-0183-Information-sheet-issue-4-1-1.pdf>.

Purpose of PPS

The PPS signal (nanosecond counter) provided by the GPS receiver is required to make the NMEA timestamp highly accurate with guaranteed reliability. The GPS unit's PPS signal frequently corrects local PPS from drifting to provide a highly accurate clock.

- Seconds count up in Unix time (seconds elapsed since 1 January 1970).
- Nanoseconds count up 0 to 999999999, when it overflows and restarts from 0.

(If the sensor continues running when input from the GPS receiver is interrupted, the sensor's internal clock will continue incrementing the timestamp in whole seconds.)

Electrical Interface and Transmission Settings

By default, the M8 sensor is set to receive GPS communication at the industry standard 4800 baud rate. Some units may allow higher baud rates to enable the transmission of more data, but other units may require a lower baud rate.

Transmission requirements and preferences may require changing the baud rate to match, as discussed in the "Managing the Sensor" section, especially page 49.

Relevant specifications are listed in Table 12.

Table 12. Electrical and Transmission Specifications

Item	NMEA	PPS
Electrical Interface	TIA-232-F compatible	LVTTTL
Voltage Level	-6 V to +6 V	+5 V maximum
Baud Rate	4800 bits per second (changeable)	NA
Data Bits	8	NA
Parity	None	NA
Stop Bits	1 (or more)	NA
Pulse Width	NA	10 milliseconds minimum

Additional notes, with reference to Figure 43:

- NMEA/PPS inputs are clamped between 0 V and 3.3 V by an overvoltage protection device.
- For zero or negative (clamped to zero) RS-232 inputs, the input is seen as logic 0.
- Voltage levels are:
 - 12 V to 0 is a valid input for logic 0.
 - +3.3 V to +12 V is a valid input for logic 1.
- You can connect TTL UART or RS-232 signals to the NMEA/PPS inputs.

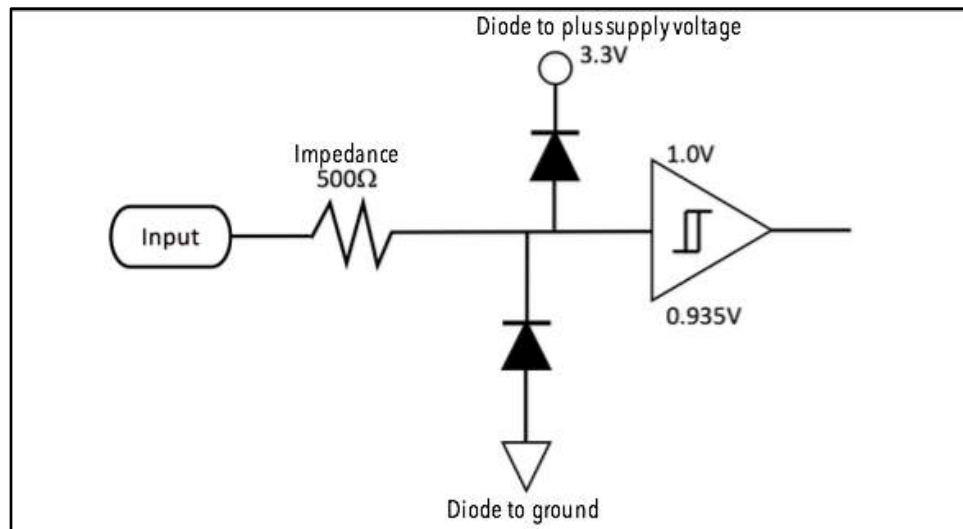


Figure 43. NMEA/PPS Input Voltages

Mechanical Interface

The M12 3-pin connector on the interface cable enables communication between the GPS receiver and the M8 sensor. The three pins are for the NMEA message, PPS signal, and ground. That signal carries through the three pins of the M19 IP67-rated connector and finally to the M8 sensor, as shown in Figure 44. For complete pinout information, refer to the “Connectors and Pins” section starting on page 27.

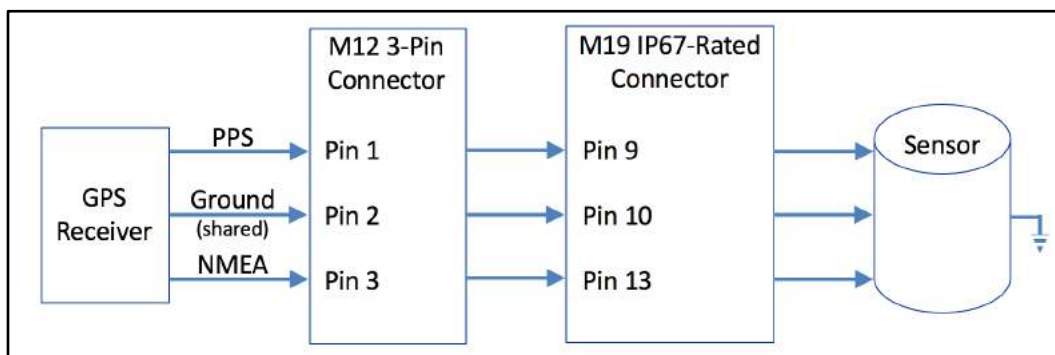


Figure 44. NMEA/PPS/Ground Communication

Data Communication

Different types of NMEA messages (called sentences) are sent from a *talker* such as a GPS receiver to one or more *listeners*, including M8 sensors. Configure the GPS receiver to send the PPS signal first, followed *only* by the \$GPRMC and/or \$GPZDA NMEA sentences. (Filter out sentences that are not used). The M8 sensor accepts the GPS unit's NMEA sentence in the \$GPRMC and \$GPZDA forms. If the GPS sends both messages, the sensor uses whichever it receives first.⁵

\$GPRMC NMEA Sentence

The \$GPRMC NMEA sentence states position, velocity, and time according to this formula, which is explained in Table 13:

Formula: \$GPRMC, hhmmss.ss,S,xxxx.xxx,N,xxxx.xxx,E,vvv.vv,aaa.a,ddmmyy,vvv.vv,W*CC

Example: \$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

Table 13. NMEA \$GPRMC Sentence Decoded

Data Field	Meaning
\$GPRMC	Message ID
\$	Indicates start of the NMEA messages
GP	GP indicates that a GPS is sending the data
RMC	Recommended minimum data (GPS/transit position, velocity, and time)
hh	hours (00-23)
mm	minutes (00-59)
ss.ss	decimal seconds (00.99-60.99)
S	status A=active or V=void
xxxx.xxx,N	latitude (disregarded)
xxxx.xxx,E	longitude (disregarded)
vvv.v	speed (disregarded)
aaa.a	course (disregarded)
dd	day (01-31)
mm	month (01-12)
yyyy	year (1970-2069)
vvv.v,W	magnetic variation (disregarded)
*CC	checksum (00-FF)

⁵ Because the NMEA 0183 standard uses a simple ASCII (text) serial communications protocol to encode its data, the data is readable when it is opened in a text editor.

\$GPZDA NMEA Sentence

The \$GPZDA NMEA sentence states date and time according to the following formula, which is explained in Table 14:

Formula: \$GPZDA, hhmmss.ss, dd, mm, yyyy, xx, yy*CC

Example: \$GPZDA, 201530.00, 04, 07, 2002, 00, 00*60

Table 14. NMEA \$GPZDA Sentence Decoded

Data Field		Meaning
\$GPZDA		Message ID
	\$	Indicates start of the NMEA messages
	GP	GP indicates that a GPS is sending the data
	ZDA	Date and time
hh		hours (00-23)
mm		minutes (00-59)
ss.ss		decimal seconds (00.99-60.99)
dd		day (01-31)
mm		month (01-12)
yyyy		year (1970-2069)
xx		local zone hours (disregarded)
yy		local zone minutes (disregarded)
*CC		checksum (00-FF)

Procedures

Step through the next few illustrations and procedures to get the M8 system to fully cooperate with the Global Positioning System (GPS) unit and enable the Coordinated Universal Time (UTC) timestamp.

Connect Single Sensor to the GPS Receiver

Figure 46 illustrates the sending of the NMEA sentence and PPS signal from the GPS receiver to a *single* sensor.

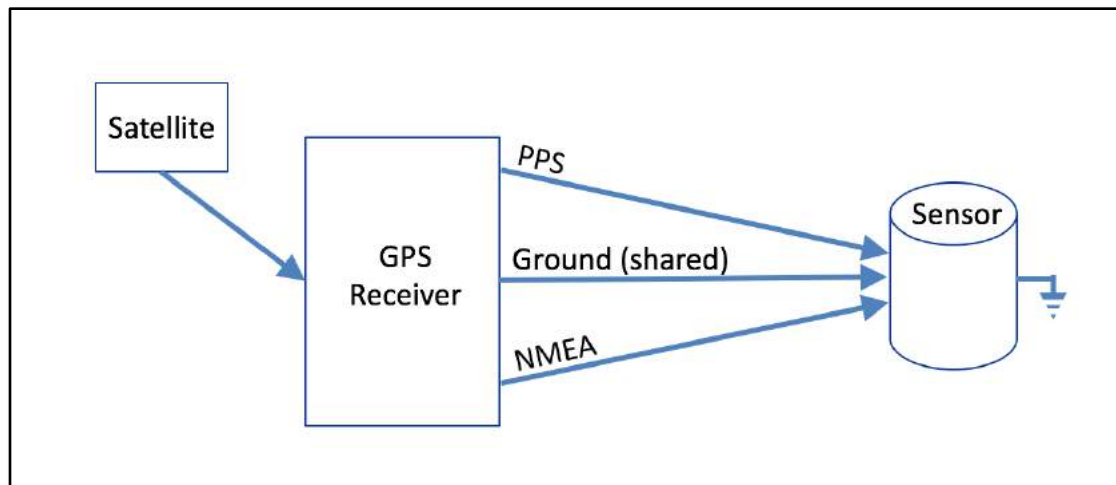


Figure 45. NMEA/PPS Signals Synchronized on Single Sensor

Connect Multiple Sensors to the GPS Receiver

If the NMEA sentence and PPS signal are sent from the GPS receiver to *multiple* sensors:

- Use identical cable lengths to connect to each sensor and prevent timing issues.
- Split and amplify signals using distributors (Figure 46) to keep the signal edges sharp and strong. We recommend that you distribute the PPS signal with the PRL-414B-BNC (Figure 47).⁶

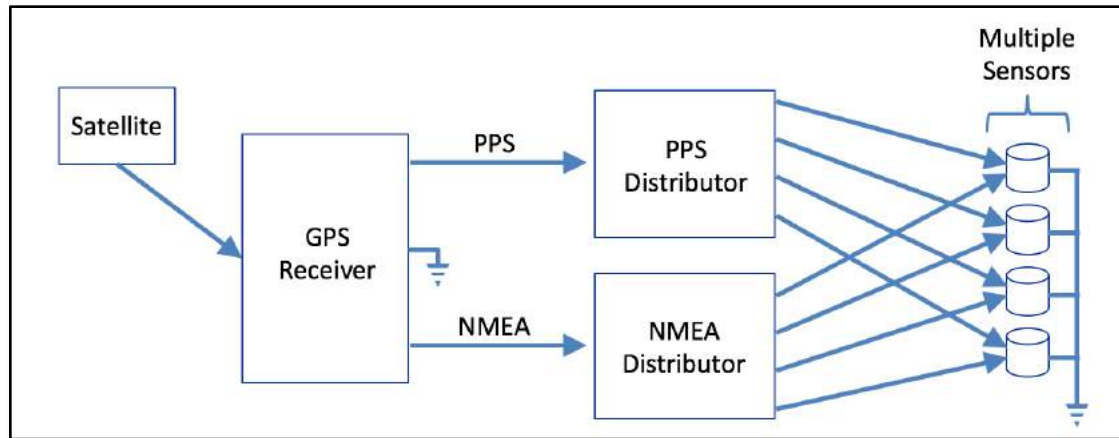


Figure 46. NMEA/PPS Signals Synchronized on Multiple Sensors

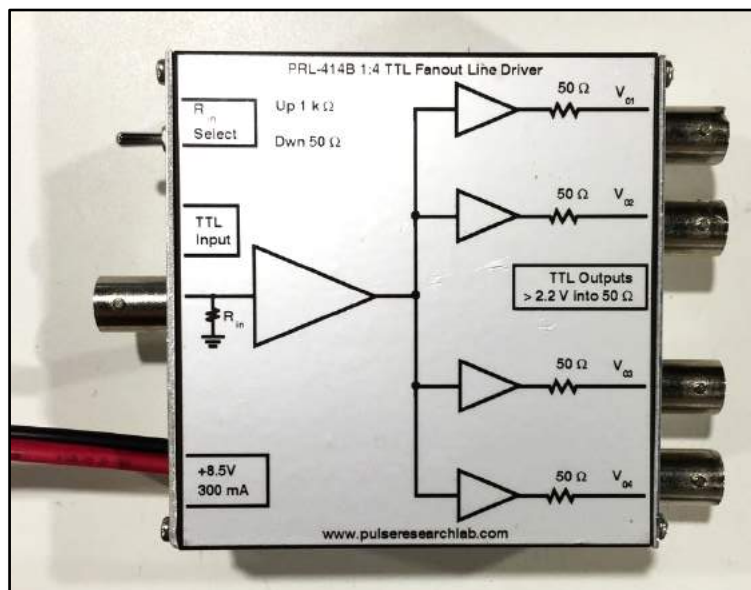


Figure 47. NMEA/PPS Signals Distributed by PRL-414B-BNC Buffer Amplifier

⁶ For more details, refer to http://www.pulseresearchlab.com/products/fanout/prl-414B/prl-414B_main.htm.

Configure the GPS Settings

The PPS signal from the GPS aligns with the NMEA signal as shown in Figure 48, where the PPS is active high and universal asynchronous receiver/transmitter (UART) is active low.

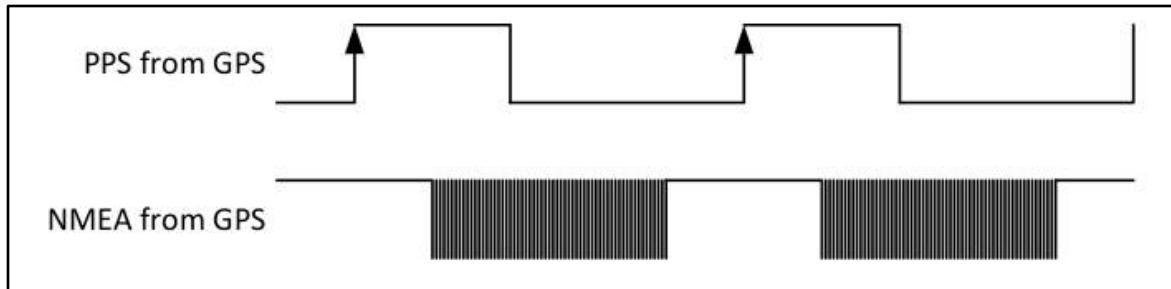


Figure 48. Normal Alignment: Positive PPS (top), Active Low NMEA (bottom)

However, the M8 Sensor Settings Management (web server) user interface allows you to make some decisions (Figure 49) relative to those signals, as discussed in the “GPS Settings” section on page 49, and as follows.

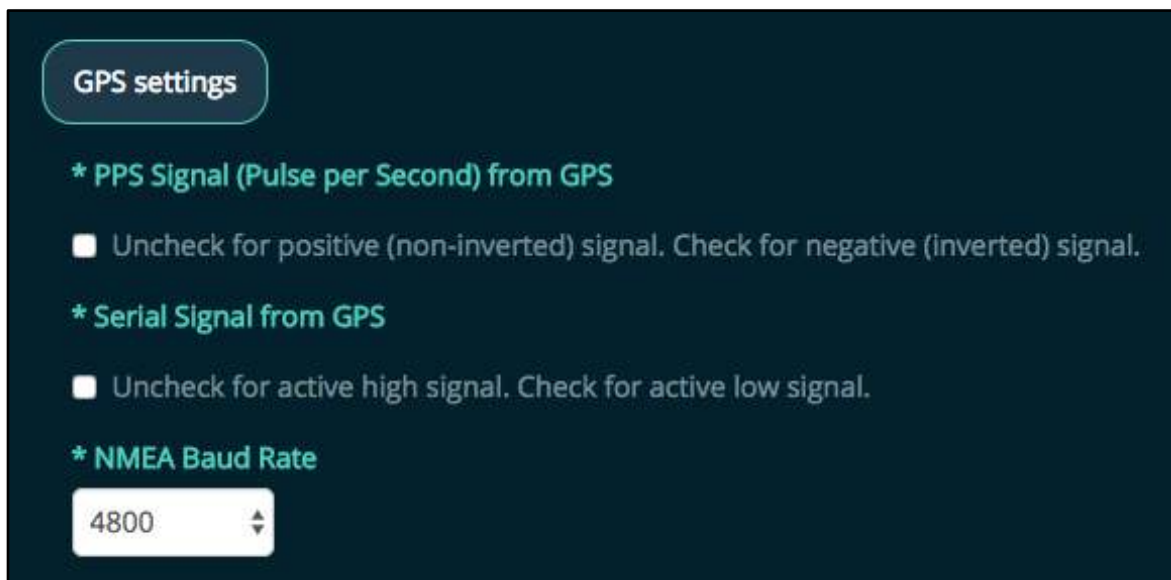


Figure 49. Web Server: GPS Settings

PPS Signal. Configure the sensor to accept a positive (non-inverted) or negative (inverted) PPS signal from the GPS device.

For positive PPS from GPS, uncheck the box.



* PPS Signal (Pulse per Second) from GPS

☐ Uncheck for positive (non-inverted) signal. Check for negative (inverted) signal.

For negative PPS from GPS, check the box.

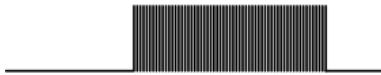


* PPS Signal (Pulse per Second) from GPS

☒ Uncheck for positive (non-inverted) signal. Check for negative (inverted) signal.

NMEA Signal. Configure the sensor to accept a NMEA signal in either active high or active low mode from the GPS device.

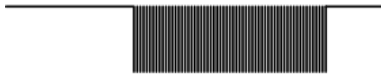
For active high NMEA from GPS, uncheck the box.



* Serial Signal from GPS

☐ Uncheck for active high signal. Check for active low signal.

For active low NMEA from GPS, check the box.



* Serial Signal from GPS

☒ Uncheck for active high signal. Check for active low signal.

Baud Rate Synchronization. Configure the NMEA serial baud rate to be in sync with the GPS serial data rate.

* NMEA Baud Rate

4800

Synchronize Sensor with GPS Timestamp

When the GPS receiver is connected to the M8 sensor and turned on, the incoming NMEA/PPS signals can synchronize with the sensor.

Windows or Ubuntu Without ROS Driver. If the M8 sensor system is operating *without a ROS driver*, the TCP packets are automatically UTC timestamped, as indicated in Table 5.

Ubuntu With ROS Driver. If the M8 sensor system is operating via the SDK *with a ROS driver*, take the following steps in order to make sure the points have the correct UTC timestamp and the `/Sensor/points` ROS topic is populated.

1. Disconnect or turn off the GPS receiver. (This will allow you to distinguish between the sensor's own timestamp and the GPS receiver's timestamp later in this procedure.)

2. Open a terminal window, and execute the following commands:

```
$ roscd quanergy_client_ros
$ cd settings
$ sudo gedit client.xml
```

3. In the client.xml file that opens up in the text editor:

- Find the `<useRosTime>` switch; change the default value (`true`) to `false` as follows:
`<useRosTime>false</useRosTime>`
- The value must be `false` for NMEA to work, so it's a good idea to document that by adding the following comment (or similar) after the `<useRosTime>` switch:
`<!-- when using NMEA, set this value to false -->`
- Save and exit the file.

4. Execute the command `rostopic list`. Check the resulting list for the proper capitalization (`/sensor/points` or `/Sensor/points`) to use in the next step.

5. Display the timestamp *from the sensor only* by executing this command:

```
$ rostopic echo /Sensor/points/header/stamp
```

You will see a display of seconds incrementing from zero, as counted up from the sensor's internal clock, which resets when the sensor is power cycled.

6. Reconnect the GPS receiver to the M8 sensor, and power it on.

7. Wait about thirty seconds for signals to fully synchronize with the sensor. (Once synchronization takes place, you will be able to see a display of the timestamp in real time.)

8. Display the timestamp *with NMEA/PPS input* by executing this command:

```
$ rostopic echo /Sensor/points/header/stamp
```

The return will look similar to this:

```
secs: 1504238913 <== UNIX Epoch time (Number of seconds since Jan 1, 1970)
nsecs: 75048100 <== Nanoseconds
---
secs: 1504238913
nsecs: 848061000
```

Check the GPS Signal Lock

For *M8 Sensor Rev D5*, check the Status tab in the web server as discussed in the “GPS Settings” section on page 49 to confirm that:

- The GPS signal from the satellite is locked (True).
- The Seconds are counting up from the epoch time.
- The Nanoseconds are between 0 and 999999999.

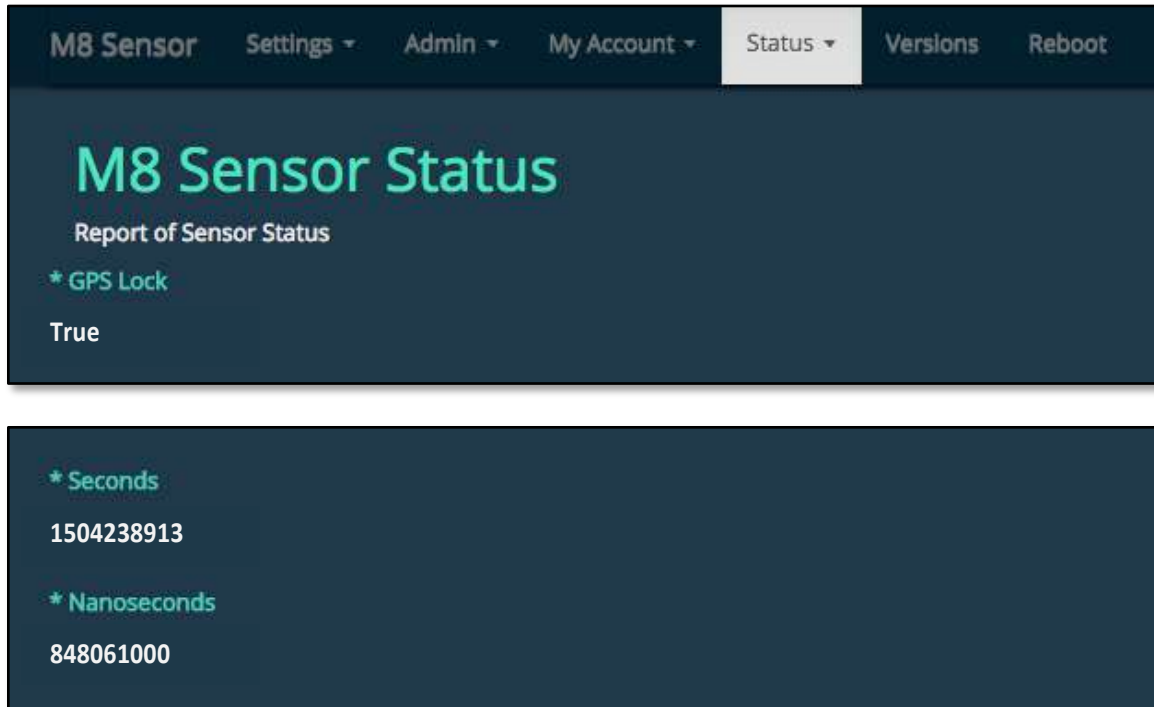


Figure 50. Web Server: Status Tab Report for GPS and UTC Timestamp

Appendix 2: Sensor Mounting and Accessories

The M8 sensor dimensions are provided in this appendix to help you design mounting configurations. Refer also to the "Mounting the Sensor" section on page 22.

Sensor Dimensions

The sensor's round mounting base, which *must remain attached*, can mount to a custom surface.



WARNING: The sensor's detachable, rectangular base plate (400g aluminum) provides a platform for the sensor and dissipates heat produced by the sensor's electronics and motor, keeping the sensor's operating temperature range within -20°C to +60°C (-4°F to +140°F). If removed, *substitute a heat sink of similar or greater thermal mass to prevent the sensor from overheating and enhance its longevity.*

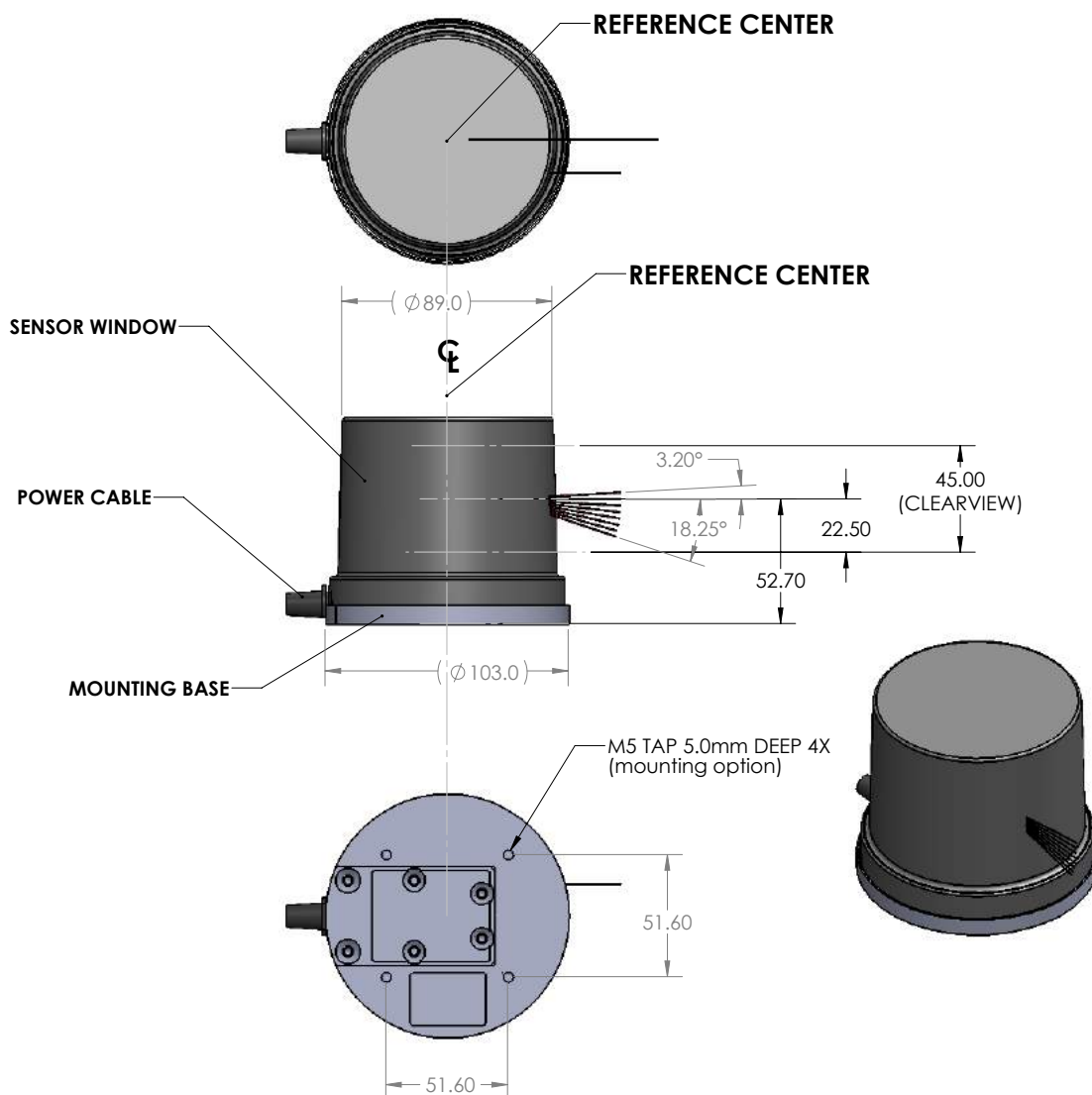


Figure 51. M8 Sensor Mounting Drawing of Sensor

Base Plate Dimensions

When attached to the sensor, the rectangular base plate's four M3 threaded corner holes are used to mount securely to a surface.

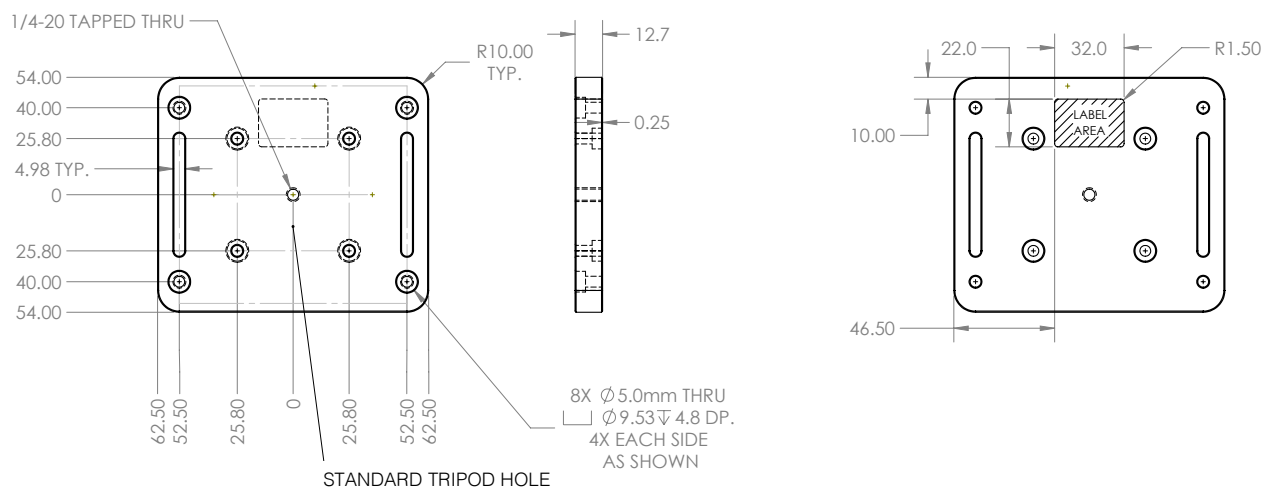


Figure 52. M8 Sensor Mounting Drawing of Rectangular Base Plate

Accessory for Mounting

Some implementations of the M8 sensor are easier to achieve with the specialized Adjustable Mount accessory available for purchase from Quanergy. This accessory attaches to either a flat surface or a pole, and it adjusts for roll and pitch, as explained on page 80.

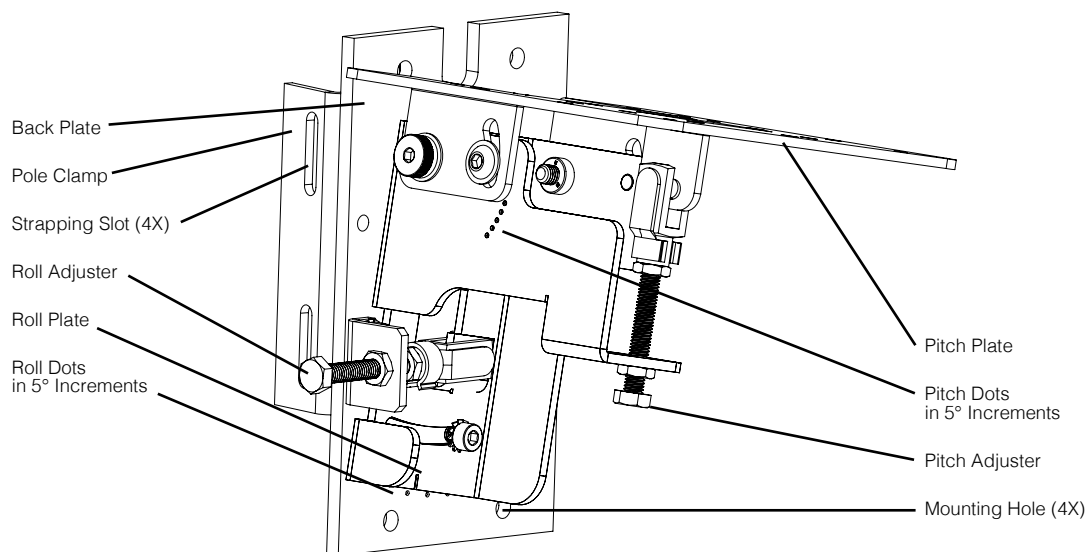


Figure 53. M8 Sensor Adjustable Mount Accessory

Accessory for Weather Shielding

The Adjustable Mount can include an optional Weather Shield accessory (Figure 54) that you may purchase from Quanergy to protect the sensor from weather and solar loading. The “Address Environmental Concerns” section on page 83 explains how to install the Weather Shield.

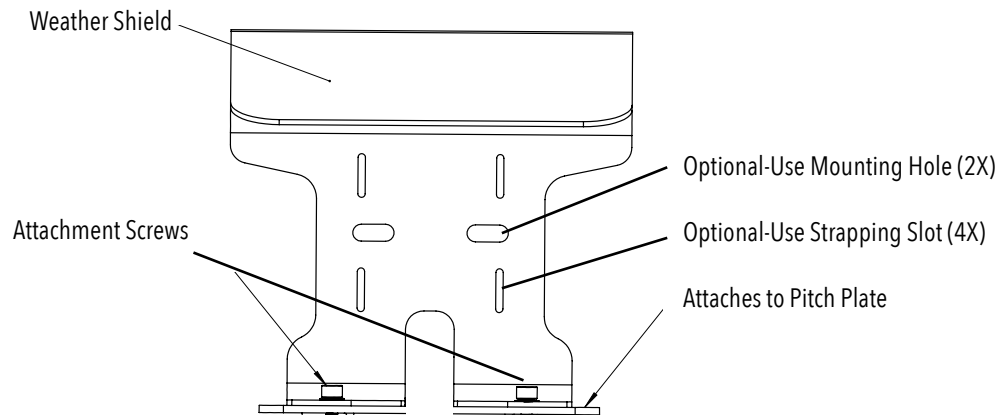


Figure 54. M8 Sensor Weather Shield Accessory

Installation of Accessories

For best results in outdoor environments, Quanergy recommends mounting the Weather Shield over the M8 sensor on an Adjustable Mount that is strapped to a pole or affixed to a flat surface. For indoor environments, the Weather Shield is not necessary.

The following procedures explain how to install the M8 sensor using these accessories to fit your needs. Refer to Figure 53 and Figure 57.

Gather Resources

You will need the following resources and tools to accomplish the procedures in this “Installation of Accessories” section:

- Two people to perform the procedure.
- Hex Allen Keys to loosen and tighten various screws.
- Socket Wrench to adjust the pitch and roll.
- Procedure-specific items are listed as needed in the instructions.

Apply Force

Adhere to the following recommended torque values (inch. nom.) to use in the following hardware adjustment procedures:

- For M5 screw size, apply 8 ft-lb (10.8 N-m)
- For M6 screw size, apply 10 ft-lb (13.6 N-m)
- For M8 screw size, apply 18 ft-lb (24.4 N-m)

Determine Which Mounting Surface

The following procedures explain the installation of the Adjustable Mount on either a pole or a flat surface.

Mounting to a Pole

The Adjustable Mount (Figure 53) is pre-configured for pole mounting (Figure 55). The pole must be at least 5 cm (2 in) in diameter. Install as follows:

1. Acquire metal strapping and cincher (and optional plastic tie wraps) long enough to wrap around the selected pole.
2. Prepare the installation site with a pole that is strong, sturdy, and securely embedded in a solid foundation.
3. Make sure the pole clamp is securely screwed into the Adjustable Mount back plate.
4. Position the pole clamp with the open end pressed against a vertical length of the pole.
5. If you have tie wraps, thread them through the pole clamp slots and around the pole, then tighten. This step is optional, but allows you to position the Adjustable Mount before tightening it more or less permanently.
6. Maneuver the Adjustable Mount until it is exactly where it should be on the pole.
7. Thread metal strapping through the pole clamp slots and around the pole; cinch down.
8. Cut off the plastic tie wraps that are no longer necessary.

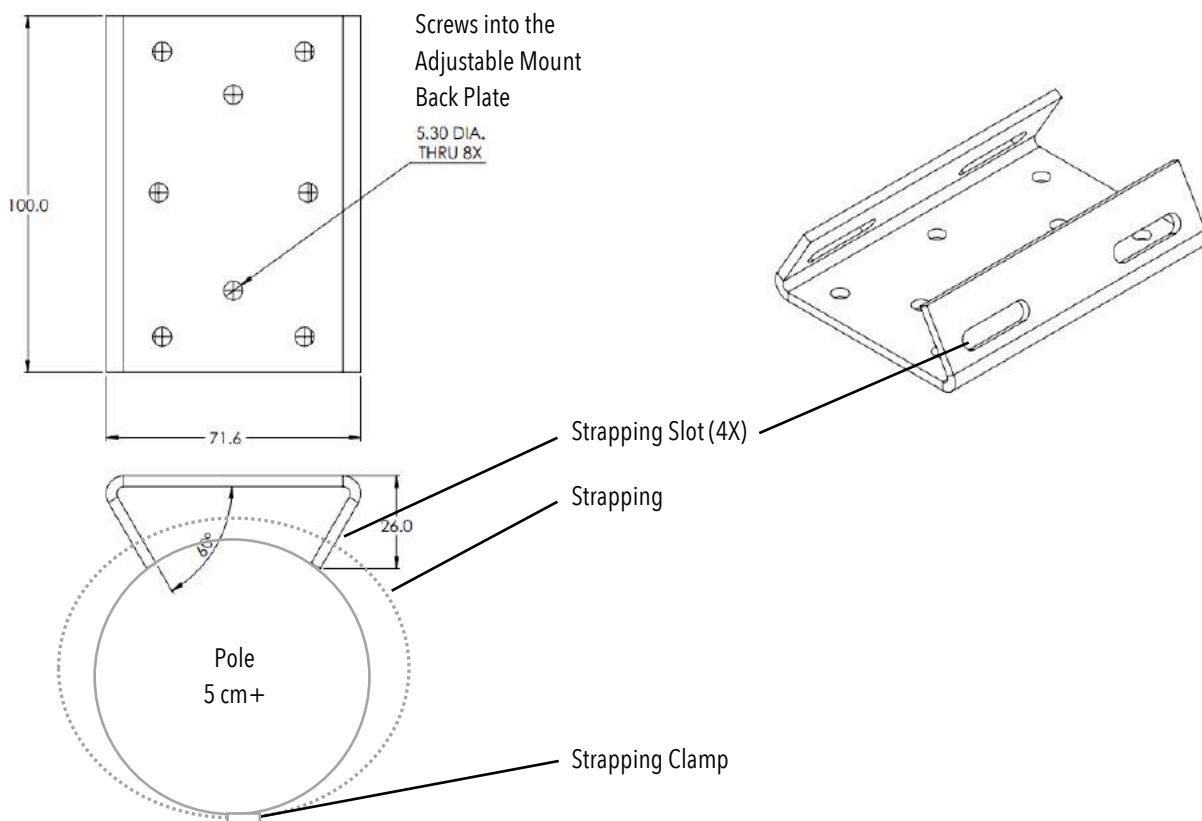


Figure 55. Adjustable Mount's Pole Clamp

Mounting to a Flat Surface

Mount the Adjustable Mount (Figure 53) to a flat surface such as a wall, as follows:

1. Unscrew and remove the pole clamp (Figure 55) from behind the Adjustable Mount's back plate.
2. Prepare the installation site:
 - Identify where you want to install the Adjustable Mount.
 - Mark and drill holes where needed, as indicated by the mounting holes in the back plate and dimensions in Figure 56.
3. Attach the Adjustable Mount's back plate to the surface using your preferred fastening hardware and the previously drilled holes.

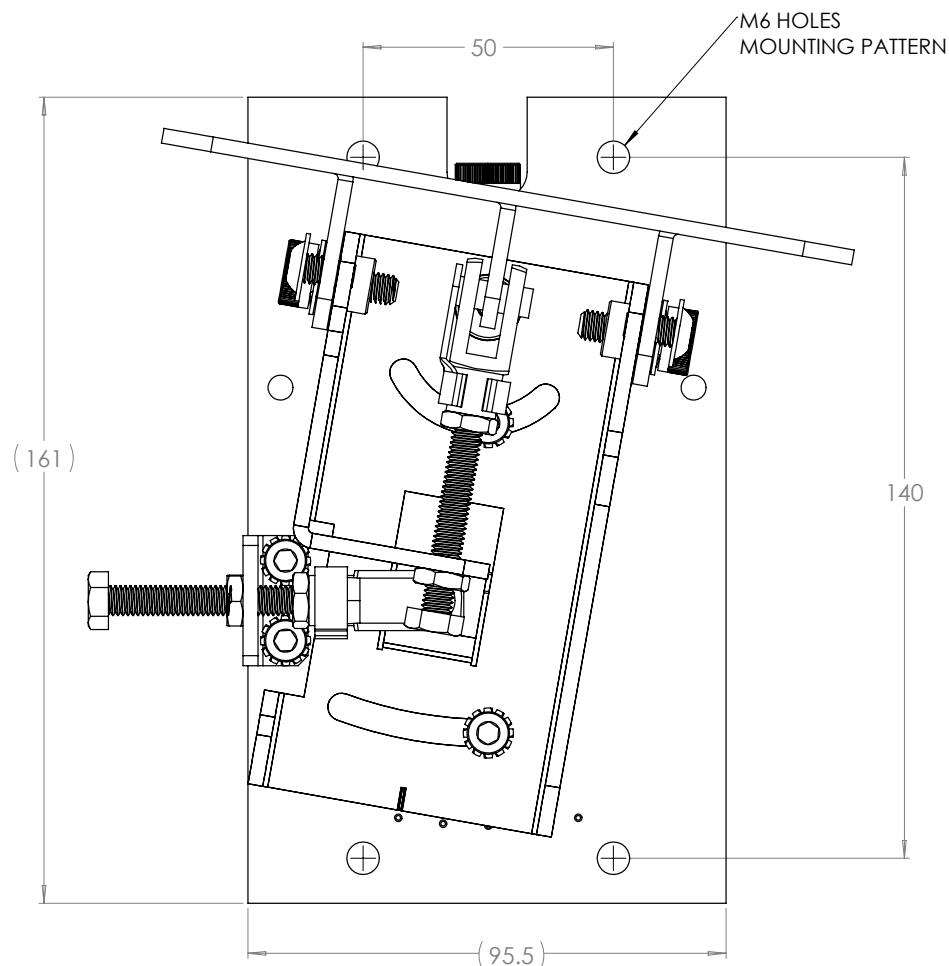


Figure 56. Adjustable Mount's Back Plate

Address Environmental Concerns

If the installation environment is likely to receive heavy exposure to sun, heat, or precipitation, you may prefer to protect the M8 sensor by adding the optional Weather Shield accessory (Figure 57). This may be used with or without the Adjustable Mount.

With the Adjustable Mount

Install the Weather Shield accessory *with* the Adjustable Mount, as follows:

1. Place the Weather Shield on the Adjustable Mount pitch plate.
2. Slide the Weather Shield toward the rear of the pitch plate.
3. Align the Weather Shield screw holes with the pitch plate's rear screw holes.
4. Screw through the rear lip of the Weather Shield accessory and into the pitch plate.

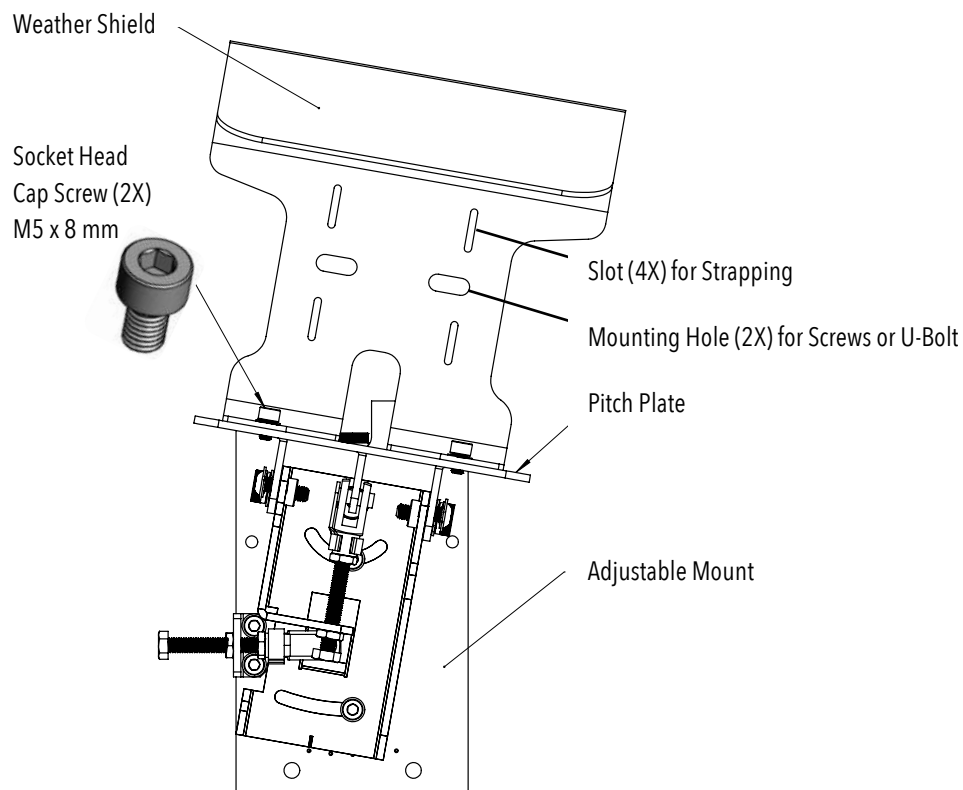


Figure 57. Weather Shield Installation

Without the Adjustable Mount

The Weather Shield accessory can be fastened to a pole or flat surface *without* the Adjustable Mount by making use of the strapping slots and mounting holes (Figure 57).

Add the Sensor

When the Adjustable Mount is firmly affixed and stable, attach the M8 sensor as follows:

1. If the Weather Shield is attached to the Adjustable Mount, thread the M8 sensor cable out the back through the keyhole opening at the bottom of the Weather Shield.
2. Use your preferred fastening hardware to attach the M8 sensor with its attached rectangular base plate (Figure 52) to the pitch plate.

Adjust Pitch and Roll

Even after the Adjustable Mount is firmly affixed to the preferred surface, you can adjust the M8 sensor's position by making a pitch adjustment (rotations around the X-axis) and/or a roll adjustment (rotations around the Y-axis).

1. If you need to adjust the sensor's pitch *and* roll, loosen all locking nuts and screws below the pitch plate *except* for the items circled in red in Figure 58. Otherwise, loosen only the items pertaining to the pitch *or* roll adjustment.
2. Make the adjustments discussed in the following "Pitch Adjustment" and/or "Roll Adjustment" sections.
3. When the adjustments are satisfactory, confirm that *all* locking nuts and screws are securely tightened to hold the M8 sensor firmly in place.

Pitch Adjustment

With pitch-related locking nuts and screws loosened:

1. Use a 10 mm socket wrench to screw the sensor's *pitch adjuster* in or out.
2. Adjust pitch to the desired angle.
3. Tighten the locking nuts (four places, two on each side, 10 ft-lbs, 13.6 N-m) and the adjustment locking nut (10 ft-lbs, 13.6 N-m) to prevent drift over time.

Roll Adjustment

With roll-related locking nuts and screws loosened:

1. Use a 10 mm socket wrench to screw the sensor's *roll adjuster* in or out. This will make the pitch plate's front edge rise or fall.
2. Adjust roll to the desired angle.
3. Tighten the two locking nuts (8 ft-lbs, 10.8 N-m) and the adjustment locking nut (10 ft-lbs, 13.6 N-m) securely to prevent drift over time.

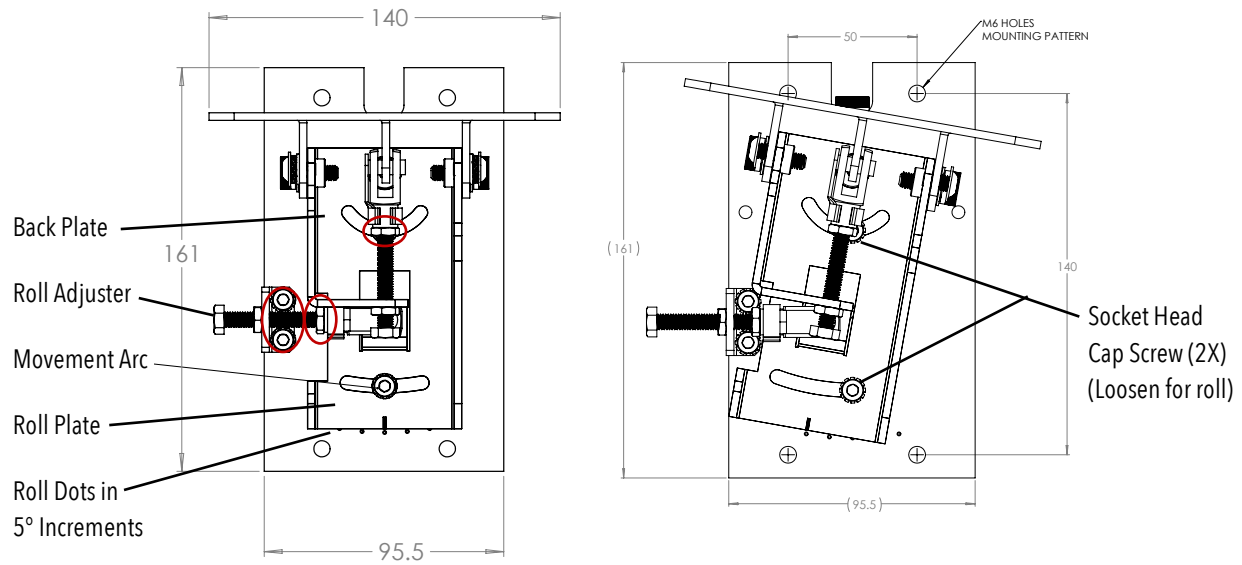


Figure 58. Adjustable Mount's Roll Adjustments

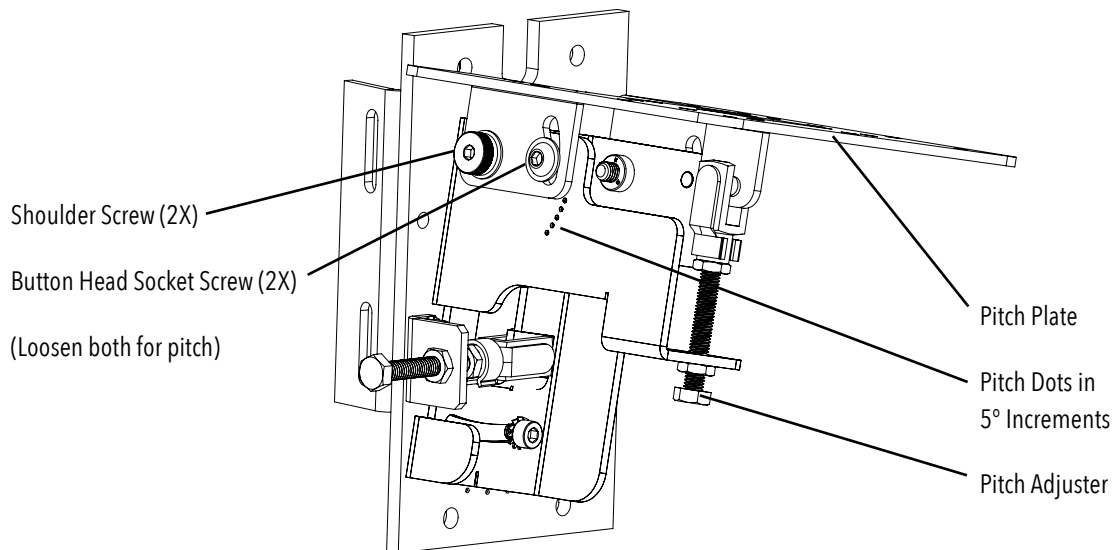


Figure 59. Adjustable Mount's Pitch Adjustments

Appendix 3: Frequently Asked Questions

Additional questions about the sensor are addressed here.

1. **Q:** What are the primary factors distinguishing the M8 from competing sensors?

A: Quanergy's M8 LiDAR sensor is typically superior in terms of price, IP69K-rated ingress protection, longer range, higher angular resolution, points per second, reliability, and ability to deal with adverse weather.

2. **Q:** Where is the serial number of the M8 sensor?

A: The entire serial number is printed on the manufacturing label that is affixed to both the rectangular base plate and the round mounting base, as shown in Figure 1.

3. **Q:** What is the voltage range for the M8 sensor?

A: 24 VDC $\pm$ 1.2 V.

4. **Q:** How robust is the M8 sensor in terms of electromagnetic compatibility (EMC)?

A: The sensor passed tests for the following EMC compliance specifications:

EN 61000-4-2 ESD

EN 61000-4-5 Surge

EN 61000-4-3 RF Immunity

EN 61000-4-6 Conducted Immunity

EN 61000-4-4 EFT

EN 61000-4-8 Magnetic Fields

5. **Q:** Under what lighting conditions will the M8 sensor work?

A: The M8 sensor works well under all lighting conditions. Quanergy tested the sensor by operating it on extremely bright and sunny days, and the performance was not affected. And in dark, zero-lighting conditions where vision-based systems are challenged, the sensor's performance was not affected.

6. **Q:** Does the M8 sensor work underwater?

A: No. 905 nm light is absorbed by water.

7. **Q:** Why does the M8 sensor have eight lasers?

A: This was the perceived optimum for the main target applications of transportation, security, industrial automation, and mapping.

8. **Q:** When does the M8 sensor's motor start and stop?

A: The sensor starts upon establishing the socket connection, and it stops after terminating the socket connection. So the sensor's socket connection determines when the motor starts and stops.

9. **Q:** If I change the rotational speed of the M8 sensor within the 5-20 Hz valid range, what happens to the laser fire timing? Does rotational speed affect heat production?

A: Changing the frame rate does not affect laser fire timing, nor does it have a significant effect on heat production. The angular resolution will change as a result of the changed rotational speed under constant firing timing. The 10 Hz frame rate (recommended for most applications) corresponds to 0.06 degree angular resolution.

10. **Q:** Is the M8 sensor's plastic lens cap field serviceable?

A: Do not open the sensor! Per terms of sale, purchaser agrees to not disassemble, reverse assemble, or modify the sensor, nor allow a third party to do so. A support representative may update the cap in the field if absolutely necessary.

11. **Q:** We want to put the M8 sensor behind a plastic enclosure to protect it from scratches and damage, as well as make it more difficult to tamper with or remove. What materials do you recommend that interfere minimally with the LiDAR?

A: Any protective material that has good transparency in the 905 nm wavelength should work well. There are two options in particular:

- For use in an R&D environment, you can use the *Gray* plastic sheet available at: <http://www.mcmaster.com/#8505k11/=12vgtuj>
- For a production deployment, you can use the Lexan SLX2432 material to mold a piece that fits into your system without blocking the optical opening of the sensor. We recommend a thickness of 1.5 mm, but it can be thicker or thinner.

NOTE: Adding material can affect range, depending on its transparency and thickness. Curving the material's surface can impact range, sometimes significantly, depending on the radius of the curvature.

12. **Q:** What should we do with M8 sensors that we no longer need or are at end-of-life?

A: Please contact your support representative to discuss disposal or return options suitable for the particular factors in your situation.

Index

\$

\$ Ubuntu prompt	32
\$GPRMC	69
\$GPZDA	69, 70

9

905 nm	26, 86, 87
--------------	------------

A

Adjustable Mount accessory	78, 79
alcohol	64
application	
Q-View	17, 31
sensor management	32, 38
area of interest	23

B

base plate, detachable rectangular	14, 22, 23, 24, 77, 78
base, round mounting	22, 23, 24, 77
baud rate	49, 74
beam	20, 36, 48
Big Endian	33

C

cleaning	64
client.xml file	75
compatible	29
compliance	11, 12, 13
computer accessories	18
contact	2
cross-talk, sensor	26

D

D4:C9:B2	32
damage	11
data packets	36, 74
data rate	74
DHCP server	30
diagnostics	65
disconnect	16, 51
disposal of sensor	87
documents	18
drone	25

dynamic IP	30, 31, 51
------------------	------------

E

EMC	86
end-of-life, sensor	87
environment, computing	17, 29, 40, 61, 74
error	63
Ethernet	15, 18, 29, 31, 33, 40

F

factory defaults	29, 50
fail safe mode	59
FAQ	86
features	19, 20
field of view	37, 46
frame rate	36, 44, 87

G

GitHub	17
GPS	15, 18, 29, 49, 66, 69, 71, 72, 73, 74
ground	15, 29, 68

H

heat sink	22, 23, 24, 64
-----------------	----------------

I

indoor	24, 25
infrared (IR) scope	65
interface cable	15, 27, 68
IP address	29, 30, 31, 32, 40, 44, 59
IP67	14, 15, 27, 68
IP69K	13, 19, 86
ISO certified	2

L

label	31, 32
laser	36, 86
firing detection	65
firing position	37
lens cap	64, 87
lighting conditions	19, 86
log in	42

M

M8 distinguishing features	86
MAC address	31, 32
maintenance	11
mapping	20, 24
models, Core, Plus, Ultra	19
mount	22, 23, 24, 25, 26, 77, 78, 79
multiple returns	20, 48
multiple sensors	18, 72

N

NMEA	15, 19, 49, 66
------------	----------------

O

object detection	23
------------------------	----

P

packet data	33
password	53, 54
pinout	27, 28
plastic	87
platforms	19
Port 4141	33
power	15, 16, 18, 29, 58, 60, 64
PPS	15, 19, 49, 66

Q

Q-View	17, 31, 65
--------------	------------

R

range	19, 48
reboot	58
recommendation	15, 18, 29, 42, 80, 87
repair	11
reset IP	59
restart	61
restore defaults	50, 51
rotational speed	36, 44, 87

S

safety	11, 23
SDK	17
security	25, 26
sensor cable	14, 15, 27
sensor management	

application	32, 38
close application	60
log in	42
open application	40
password	53
welcome	43
separation barrier	26
serial number	14, 31, 32, 43, 86
service	11
shut down	61, 64, 86
signal amplifier	72
social media	2
specifications	19
static IP	29, 30, 31, 51, 59
status	54, 62
subnet	32, 59
support	2, 11, 14, 16, 17, 62, 65, 87
surveillance	25

T

TCP connection	17, 29, 31, 33, 61
temperature, operating	22, 77
testing	24
timestamp	36, 66, 74
torque values, hardware	80
tripod	23, 24

U

Ubuntu	17, 29
Unix time	67
URL	
fail safe mode	60
open application	42
reset IP	60

V

vehicle	23, 24
versions	56, 57
voltage range	86

W

warranty	15
water	14, 15, 19, 25, 27, 64, 86
Weather Shield accessory	79
Windows	17



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