M8 Sensor User Guide

Notices

ISO 9001:2008 Certified

Contact

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For purchases made directly from Quanergy:
contact support@quanergy.com

For purchases from a third party such as
value-added reseller/system integrator:
contact them for support

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 5, Figure 6, Figure 13, Figure 21, Figure 25, Figure 32. Added Tables 1-3, Figure 15, Figure 14, Figure 24, and back cover.
C	08/25/16	Complete revision for sensor Rev B1: Fixed errors (Table 3, Figure 24). 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 (p36), and the PPS/NMEA configuration text. Moved sensor integration procedure via VM/SDK to *Sensor SDK User Guide for Ubuntu*.
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 D, amending Figure 24 to show new counter-clockwise laser firing configuration. Added overview of Q-View tool, Figure 2, Figure 3, Figure 4, Figure 18, Figure 20, Figure 23, and Table 8. 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 5, Figure 6, Figure 21, Figure 32, 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 startup procedures because the M8 sensor is now delivered from the factory in a static IP configuration, and added Figure 17 and Figure 19.

Contents

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Tables

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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 M8-1 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 M8-1 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 M8-1 LiDAR sensor has been tested and found to comply with the standards and specifications of several organizations.

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.

FDA Compliance

The M8-1 LiDAR sensor is designated Class 1 (eye safe), 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.

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.

IP69K Compliance

The M8-1 LiDAR sensor passed Water and Dust Ingress Tests in compliance with the IEC 60529 IP69K specification.

RoHS Compliance

Bills of Material components of Quanergy's 3D M8-1 LiDAR sensor and QPU Processing Unit 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 M8-1 LiDAR sensor and QPU System have been reviewed and analyzed through WEEE RRR (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 Reference 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.

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 shown on page 24)	
Manufacturing label, which combines three labels (including the model *M8-1*, revision, and serial number), as shown in Figure 1: • Manufacturer Label • Explanatory Label • Certification Label	

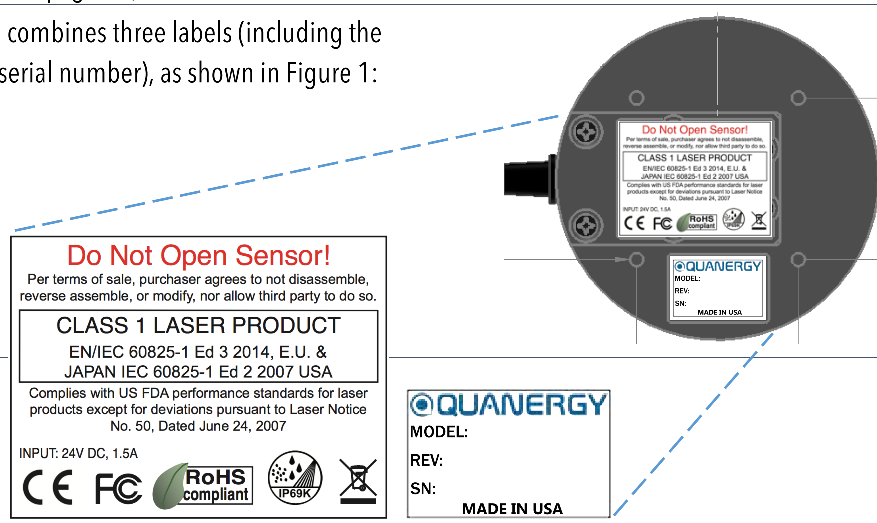

Figure 1. Sensor Manufacturing Labels

If any expected item is missing or damaged upon arrival, contact your support representative.

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. To complete the cable, you may do either of the following two options:

1. Assemble a custom interface cable suited to your specific requirements, using the specifications in the “Connectors and Pins” section on page 23.

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 24 V AC power supply).
   - 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”).

NOTE: Cutting the cable is ***not*** recommended. Such an alteration may void the warranty and incur additional repair charges.

Figure 2. Sensor Interface Cable

Power Supply

The M8 sensor cannot operate without power. Quanergy does not provide a power supply with the standard sensor system, but you may purchase a normal 24 V DC power supply from Quanergy as shown in Figure 3, which comes with its own power cable to connect the sensor to an outlet.

For development purposes, users may provide power via an appropriate power supply as specified in Table 2. Make sure the power supply 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.

CAUTION: Providing power that fails to meet the specifications may damage the M8 sensor system.

Table 2. Power Supply Specifications

Item	Specification
Output Voltage	24 V DC
Output Current	1.5 A (max)
Protection	Short Circuit Protection
	Over Current Protection
	Over Voltage Protection
Ripple	1 - 2% $V_{p\text{-}p}$ (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

Figure 3. Sensor Power Supply (bottom) and Cable (top)

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 Reference 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 only the open source Ubuntu 14.04 LTS operating system running either 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 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

Embedded Solution: Pre-configured at factory. The Quanergy Processing Unit (QPU) is pre-configured at the factory as a complete solution that conveniently includes all necessary source code, libraries, and helpful third party applications and drivers for visualizing point clouds and calibrating sensors to provide an enriched Multi-LiDAR Fusion™ perspective of a single area of interest. The option to employ multiple sensors at once requires the added hardware of an Ethernet switch (Table 3) and its power supply.

Refer to *QPU User Guide* (https://quanergy.desk.com/customer/portal/articles/2688861) and *QPU Quick Start Reference Card* (https://quanergy.desk.com/customer/portal/articles/2688860).

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
Mouse + Keyboard + Monitor	Support computing environment	Per user preference
Mounting Surface	Affix the sensor	Vehicle roof rack, camera tripod, etc.
Ethernet Switch + Power Supply	To handle multiple sensors	Netgear ProSafe GS108: recommended by Quanergy
GPS/IMU Module	Report position and supply the NMEA/PPS timing signals	OXTS RT3003, VectorNav200, NovAtel SPAN-IGM-A1: supported by Quanergy

Support Documents

Quanergy offers a suite of documents (Figure 4) to aid the user in understanding how to set up and operate the M8 sensor system. Access a list of these downloadable documents at https://quanergy.desk.com/customer/portal/articles/2725667.

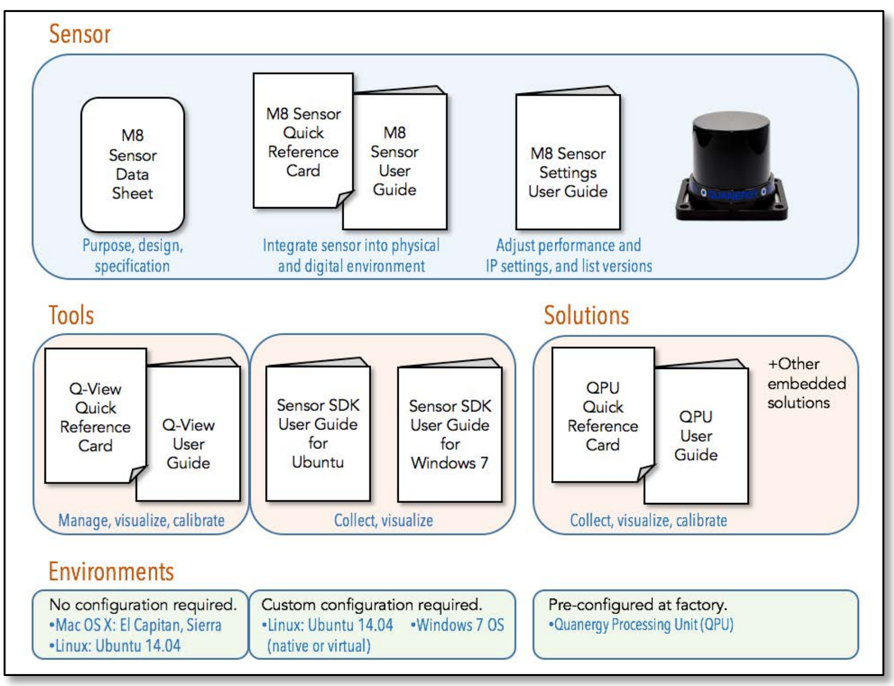

Figure 4. Roadmap of Quanergy User Documents

2. Introducing the Sensor

Quanergy's Time-of-Flight (TOF) M8 LiDAR sensor (Figure 5) enables new applications in the transportation, industrial automation, 3D mapping and surveying, and security markets.

Figure 5. M8 LiDAR Sensor

Quanergy's smart sensing technology can be applied to a variety of platforms (e.g., vehicles, robots, production tools, 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.

With a 360° field of view, long measurement range, high accuracy, fine resolution, high reliability, compact size, light weight, and low power consumption, Quanergy's compact, rugged M8 LiDAR sensor was designed to meet the demands of the most 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. 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." Linux and Windows drivers allow for easy configuration, integration, and testing.

The *M8 Sensor Data Sheet* lists the specifications defining the sensor, and it can be downloaded from https://quanergy.desk.com/customer/portal/articles/2687054.

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 6. 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.

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.

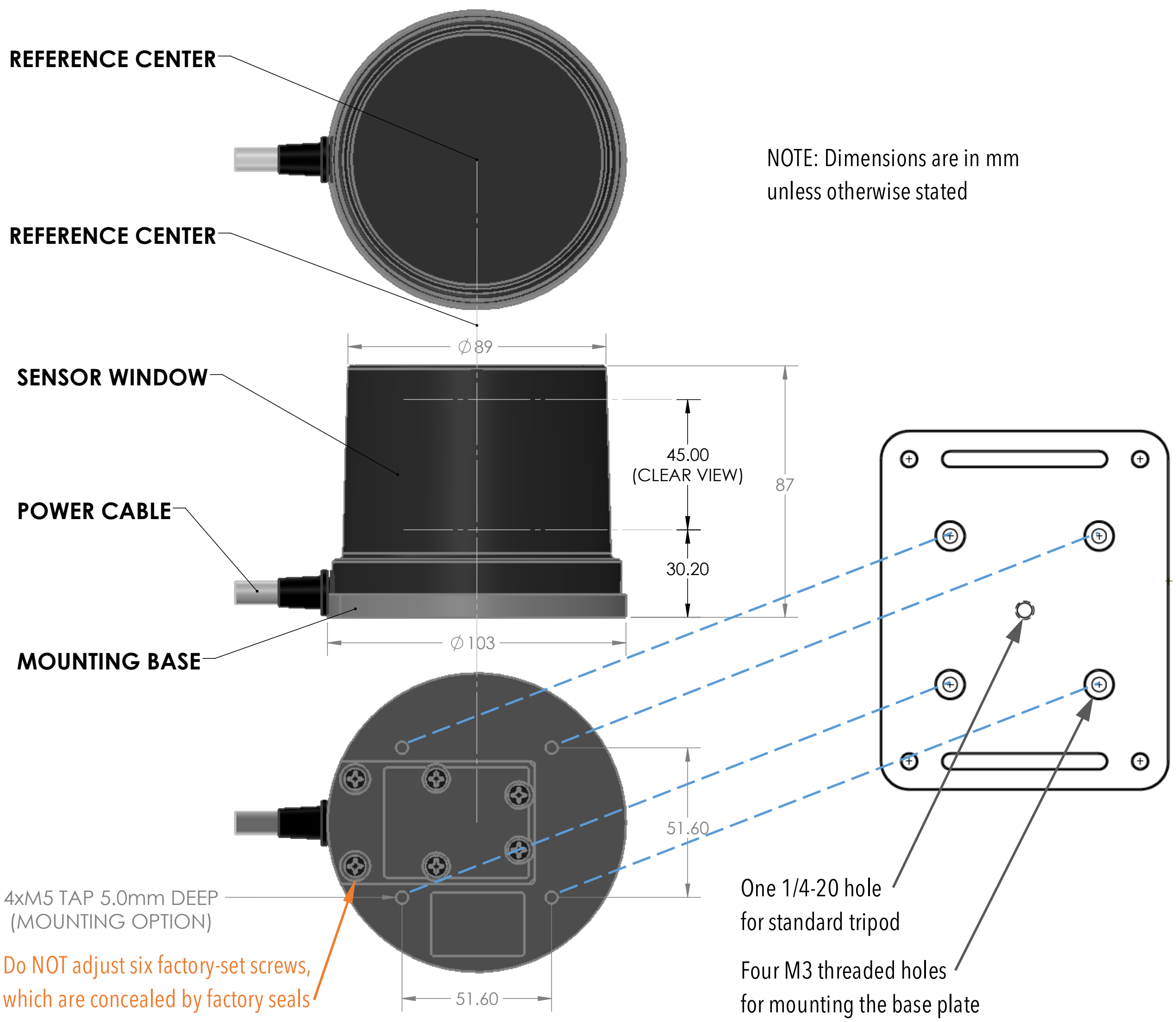

Figure 6. Permanent Mounting Base (round), Detachable Base Plate (rectangular)

Options

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.

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 7 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 7. 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 8), where the rectangular base plate is replaced with a user-provided custom heat-sink substrate screwed into the sensor's round mounting base.

Figure 8. 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 9.

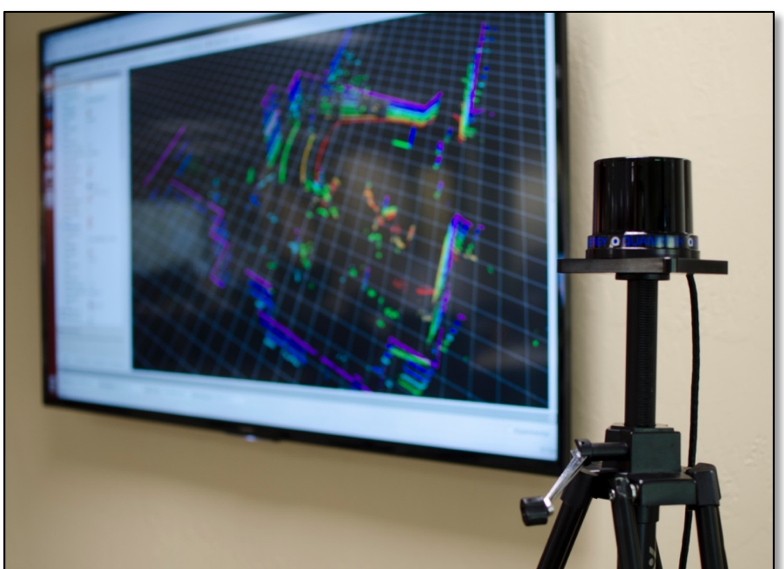

Figure 9. Indoor Tripod-Mounted Sensor with Detachable, Rectangular Base Plate

Side-Mounted on Drone Scenario

The cramped spacing of a drone provides special challenges. In the Figure 10 example, the sensor is mounted to a drone's payload at a 90° angle.

Figure 10. Drone with Side-Mounted Sensor

Ceiling-Mounted Scenario

Figure 11 shows an indoor simulation of a sensor mounted upside-down from a fixture on the ceiling.

Figure 11. Ceiling-Mounted Sensor for Upside-Down View

Wall-Mounted Security Scenario

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

Figure 12. Wall-Mounted for Security

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 13 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 13 center) and three sub-cables on the other (Figure 13 right). Recommended connectivity is illustrated in the wire color chart in Figure 14, with pin assignments shown in Figure 15 and Figure 16.

Figure 13. Pigtail M19 (left), Interface M19 (center), Interface Sub-Cables (right)

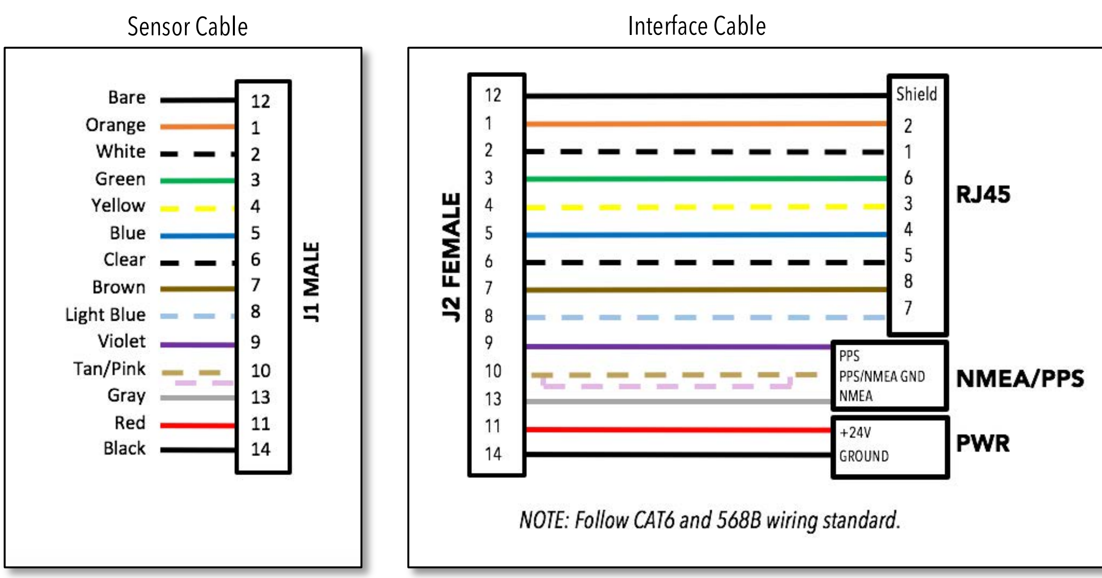

Figure 14. Pigtail Connector Wire Color (left), J1/J2/Sub-Cable Connectivity (right)

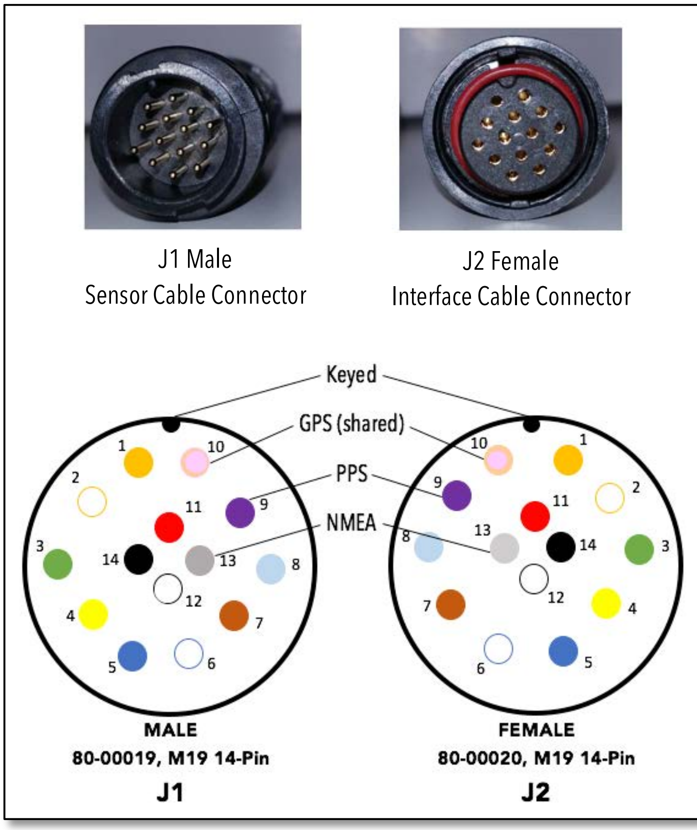

Figure 15. M19 Pinout and Photo

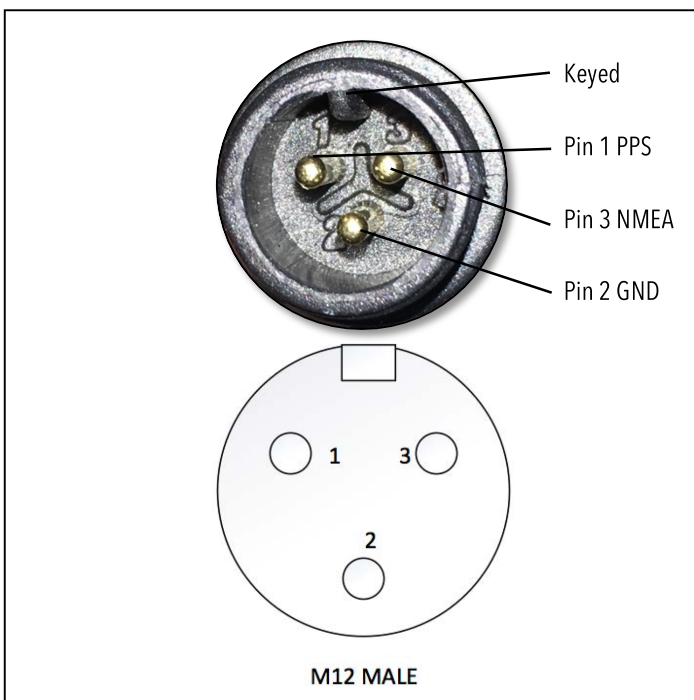

Figure 16. M12 3-Pin Pinout and Photo

4. Integrating the Sensor

Depending on which environment (Figure 4) your 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
- *QPU User Guide* — https://quanergy.desk.com/customer/portal/articles/2688861
- *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:

> NOTE: If you have a Quanergy Processing Unit (QPU), do NOT use it for this procedure! The QPU expects a dynamically set sensor that has not been configured to have a static IP address.

1. Connect the sensor directly to the host computer's network port (Figure 17).
   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 (natively or in a virtual machine) over x86-64 architecture.

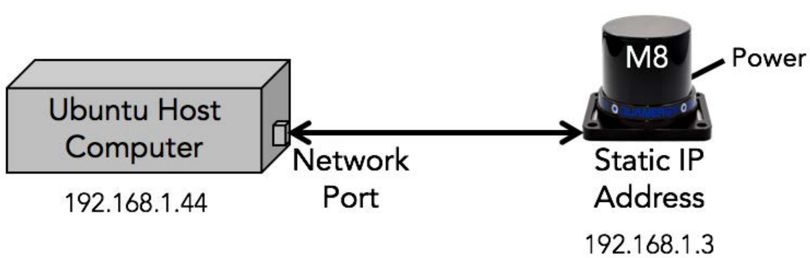

Figure 17. Sensor Connections with Static IP Address

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 4-254 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:

> NOTE: For your convenience, this is a quick summary of the procedure detailed in the *M8 Sensor Settings User Guide*, https://quanergy.desk.com/customer/portal/articles/2687040.

Open a web browser, navigate to the web server at http://192.168.1.3:7780/, login with the username `editor` password `qeditor`, and select the Settings tab. Select the *Edit* item from the Settings tab to open the *M8 Settings Edit* page.

- **For dynamic IP assignment**, click the *Dynamic* button, click the *Submit* button, disconnect the sensor from power for 2 seconds, reconnect to power, then wait 40 seconds before operating the sensor. Connect to a router that is on the same network as the host computer (Figure 18). The DHCP server will automatically assign the sensor a dynamic IP address to match the computer's network address.

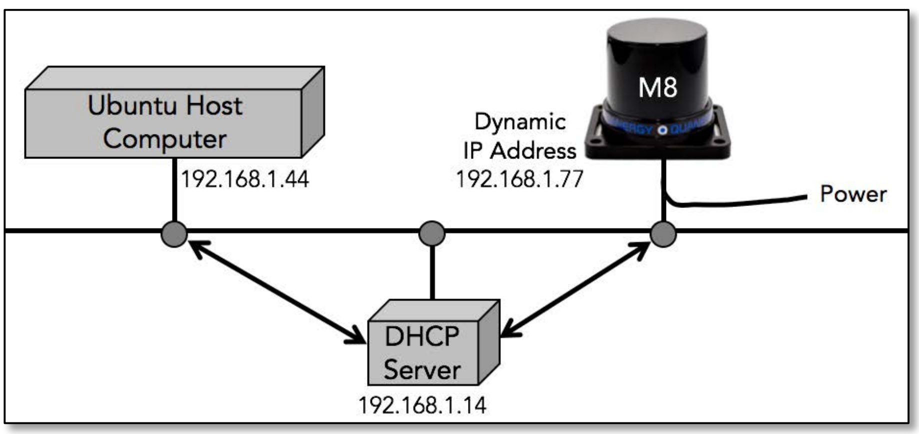

Figure 18. Sensor Connections with Dynamic IP Address

- **For static IP assignment**, click the *Static* button, click *Submit*, populate the *M8 Network Settings Edit* page with values within the network range (change the last octet of the IP address as shown in Figure 19!), click *Submit*, disconnect the sensor from power for 2 seconds, reconnect to power, then wait 40 seconds before operating it. You may connect the sensor to the same network as the host computer instead of staying directly plugged in.

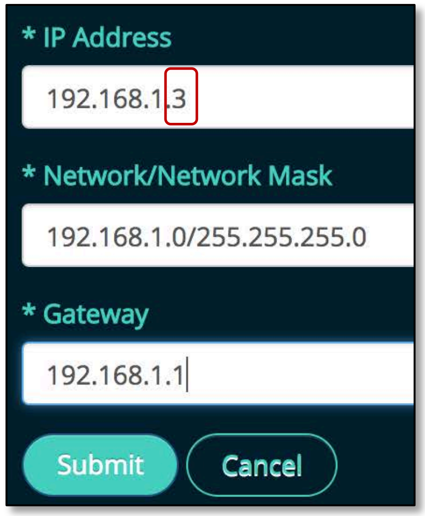

Figure 19. Sensor Static IP Address

5. To accept NMEA/PPS inputs, refer to "Appendix 1: Use of NMEA/PPS Signals" in this user guide, and connect to ground/GPS.
6. To connect multiple sensors (after they have been configured for dynamic IP assignment), refer to "Appendix 1: Handling Multiple Sensors" in the *QPU User Guide*.

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 a dynamic or static assignment, is essential for communicating with the M8 sensor over the Ethernet TCP connection. The *M8 Sensor Settings User Guide* explains in detail how to configure the sensor to accept a static or dynamic IP address. (Refer to https://quanergy.desk.com/customer/portal/articles/2687040).

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 three digits 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 three digits match the last three digits of the sensor's MAC address (Figure 21).

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

Q-View Application Reveals Serial Number and IP Address

Quanergy's Q-View application offers a quick visual discovery tool to identify sensors that have been attached to the network as explained on page 25. This convenient tool reveals each sensor's IP address and MAC address. The last three digits of the MAC address are the sensor's abbreviated serial number. (Refer to the *Q-View User Guide* at https://quanergy.desk.com/customer/portal/articles/2717074.)

Terminal Commands Reveal 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, 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
```

2. Check the MAC address of each sensor listed in the network search results as shown in Figure 21 until you find one that starts with D4:C9:B2 and ends with the three digits on the hardware sticker (e.g., 40A 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 sensor's IP address that you were looking for (e.g., 10.0.0.8 in Figure 21).

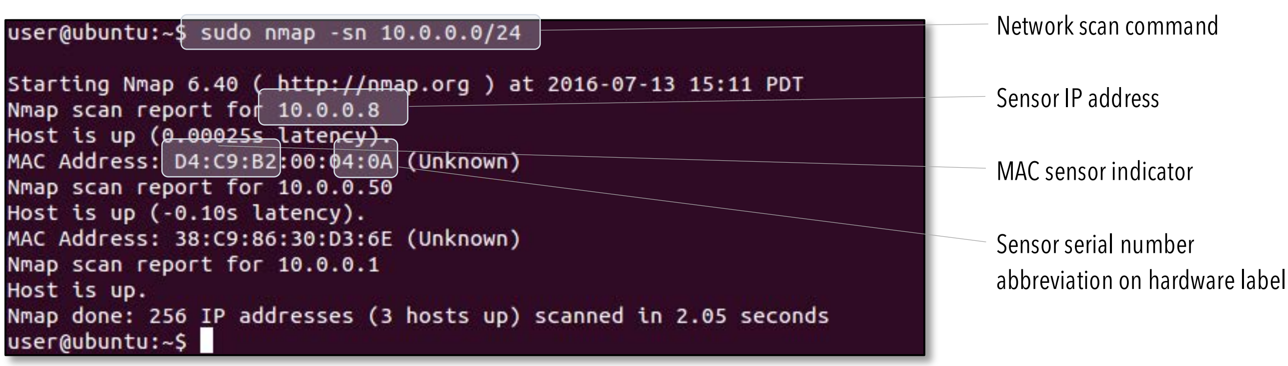

Figure 21. Finding the Sensor IP Address from the Command Line

4. Execute the following command to confirm that there is communication between the host computer and the sensor. (The ping command is shown with its example result in Figure 22.)

```
$ ping [sensor's ip address]
```

```
user@qpu-129: ~
user@qpu-129:~$ ping 10.0.0.249
PING 10.0.0.249 (10.0.0.249) 56(84) bytes of data.
64 bytes from 10.0.0.249: icmp_seq=1 ttl=64 time=0.631 ms
64 bytes from 10.0.0.249: icmp_seq=2 ttl=64 time=0.536 ms
64 bytes from 10.0.0.249: icmp_seq=3 ttl=64 time=0.531 ms
64 bytes from 10.0.0.249: icmp_seq=4 ttl=64 time=0.532 ms
64 bytes from 10.0.0.249: icmp_seq=5 ttl=64 time=0.468 ms
64 bytes from 10.0.0.249: icmp_seq=6 ttl=64 time=0.526 ms
^C
--- 10.0.0.249 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5001ms
rtt min/avg/max/mdev = 0.468/0.537/0.631/0.051 ms
user@qpu-129:~$
```

Figure 22. Ping Command to Confirm Connection

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 variable definitions for the packet formats are provided in Table 4 and Table 5.

Table 4. Variable Definitions for M8 Packet

Field	Type	Unit/Value	Notes
PACKET HEADER			
Packet Signature	uint32	0x75bd7e97	
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 below.
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)`

Field	Type	Unit/Value	Notes
M8 Firing Data			
Position	uint16	1/10400 rotation	[0, 10399] Refer to Figure 24.
Reserved	uint16		
Returns Distances	uint32[3][8]	10 micrometers	Array of distance measurements per laser (8) per return (3); the final 2 returns are always 0.
Returns Intensities	uint8[3][8]		Array of intensity measurements per laser (8) per return (3); the final 2 returns are always 0.
Returns Status	uint8[8]		Array of status per laser (8); always 0.

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.

1 out of 64 laser firings are dropped for diagnostic purposes.

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 };
```

A rough illustration of the beam angles is shown in Figure 23.

Figure 23. M8 Sensor Laser Beam Radians/Angles

The values in the code are designed for working with optics. 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 24.

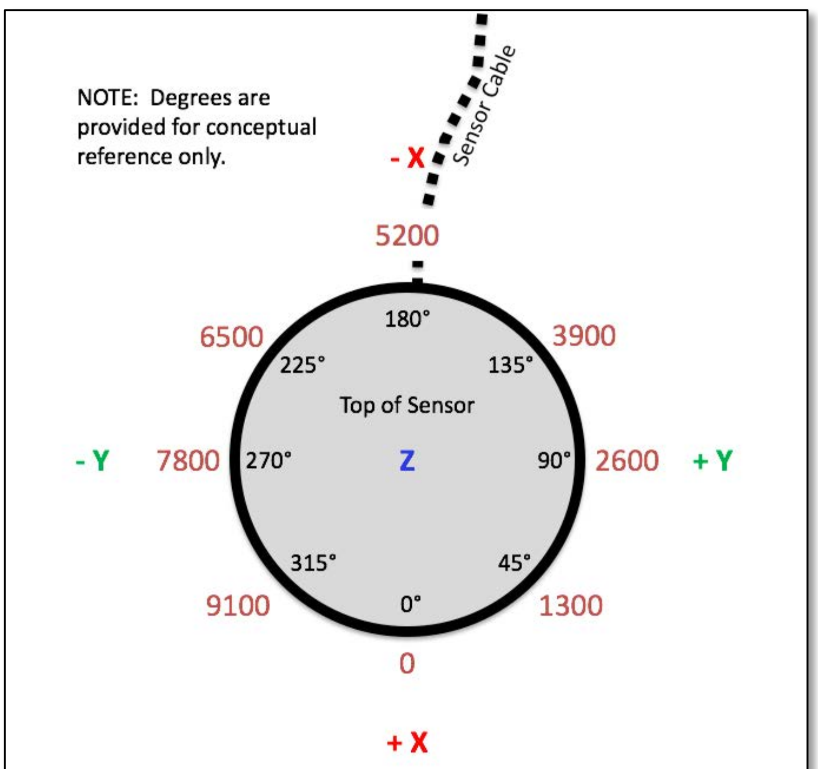

Figure 24. Laser Firing Position (Top-Down View)

6. Taking the Next Steps

Depending on which computing environment (Figure 4) your M8 sensor has integrated into, the specifics 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
- *QPU User Guide* — https://quanergy.desk.com/customer/portal/articles/2688861
- *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

To adjust the performance of the sensor, refer to:

- *M8 Sensor Settings User Guide* — https://quanergy.desk.com/customer/portal/articles/2687040

7. 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.

8. 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.

Perform Cleaning

If cleaning of the sensor 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 18.
- 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.

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.

Check an Issue

Tools and indicators can be helpful to assess a situation:

- The sensor's AC power supply 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 25) should glow steadily. If it is blinking or off, there may be a power problem.

Figure 25. Power Indicator on the AC Power Supply

- 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 26. View Sensor Through Infrared Scope

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, VectorNav200, and NovAtel SPAN-IGM-A1 GPS receivers. The Garmin GPS18x has also tested well in outdoor conditions.

Purpose

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.

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.

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.

Electrical Interface

The M8 sensor is set to receive GPS communication at the industry standard 4800 baud rate and higher. Higher baud rates enable the transmission of more data, so some units transmit at a higher rate. The *M8 Sensor Settings User Guide* explains how to change the rate. (Refer to https://quanergy.desk.com/customer/portal/articles/2687040.)

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 signals using distributors (Figure 27 bottom), to keep signal edges sharp. We recommend distributing the PPS signal with the PRL-414B-SMA (Figure 28) (http://www.pulseresearchlab.com/products/fanout/prl-414B/prl-414B_main.htm).
- 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).
- Refer to "Appendix 1: Handling Multiple Sensors" in the *QPU User Guide*, which is at https://quanergy.desk.com/customer/portal/articles/2688861.

Table 6. Communication Specifications

Item	NMEA Specification	PPS Specification
Electrical Interface	EIA-422	LVTTL
Voltage Level	–6 V to +6 V	+5 V Max
Baud Rate	4800 bits per second (changeable)	NA
Data Bits	8	NA
Parity	None	NA
Stop Bits	1 (or more)	NA

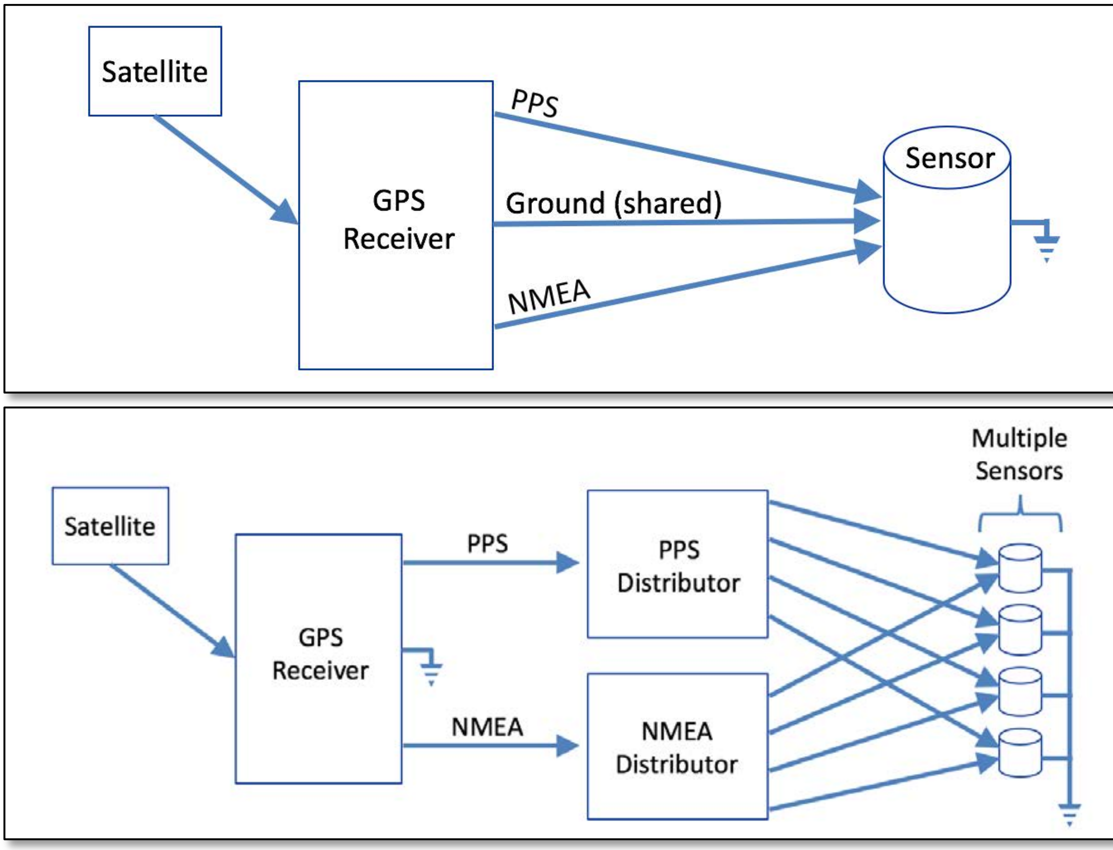

Figure 27. NMEA/PPS Signals Synchronized on Sensor (top), Multi-Sensor (bottom)

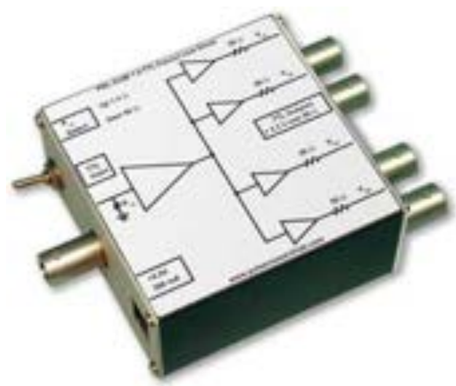

Figure 28. PPS Signal Distributed by PRL-414B-SMA Buffer Amplifier

Data Communication

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.

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.

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.

$GPRMC NMEA Sentence

The $GPRMC NMEA sentence states position, velocity, and time according to the following formula, which is explained in Table 7:

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 7. 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)

$GPZDA NMEA Sentence

The $GPZDA NMEA sentence states date and time according to the following formula, which is explained in Table 8:

Formula: `$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*CC`
Example: `$GPZDA,201530.00,04,07,2002,00,00*60`

Table 8. 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)

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 29.

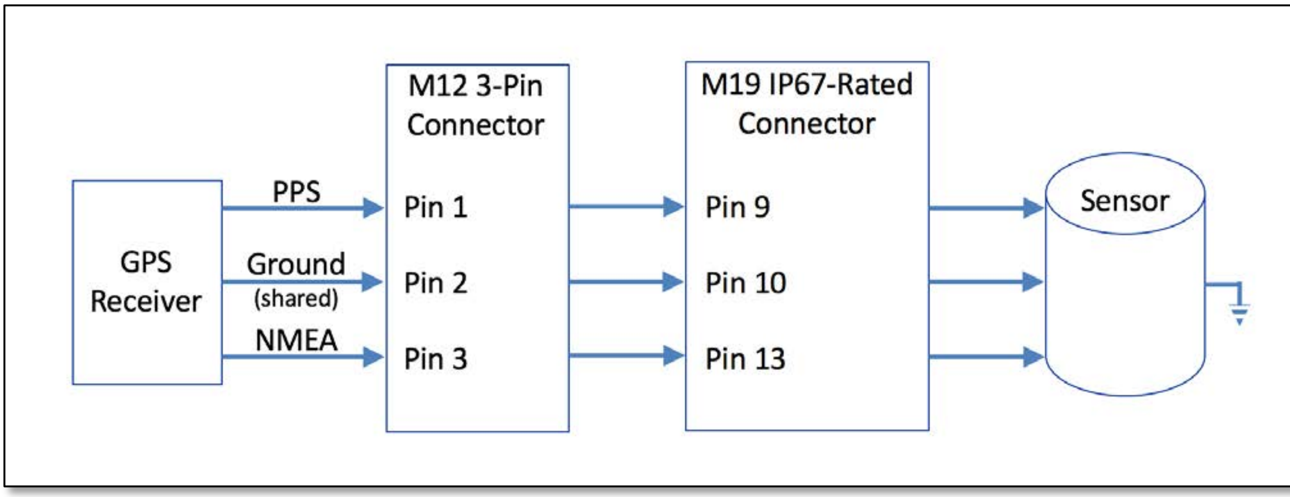

Figure 29. NMEA/PPS/Ground Communication

Note that NMEA and PPS share Ground, which is Pin 10 of the M19 connector and Pin 2 of the M12 3-pin connector.

For the complete pinout information, refer to Figure 15 and Figure 14 on page 24.

Configuration

The PPS signal from the GPS aligns with the NMEA signal as shown in Figure 30, where the PPS is active high and universal asynchronous receiver/transmitter (UART) is active low.

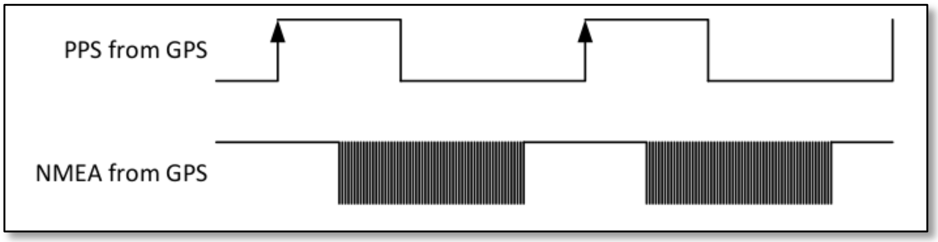

Figure 30. Normal Alignment: Positive PPS (top), Active Low NMEA (bottom)

However, the M8 Sensor Settings Management web-based user interface allows you to make some decisions, including whether to:

- Configure the sensor to accept a positive (non-inverted, as shown in Figure 30 top) or negative (inverted) PPS signal from the GPS device.
- Configure the sensor to accept a NMEA signal in either active low (as shown in Figure 30 bottom) or active high mode from the GPS device.
- Configure the NMEA serial baud rate to be in sync with the GPS serial data rate.

The *M8 Sensor Settings User Guide* (https://quanergy.desk.com/customer/portal/articles/2687040) explains how to make these changes, the relevant part of which is shown in Figure 31.

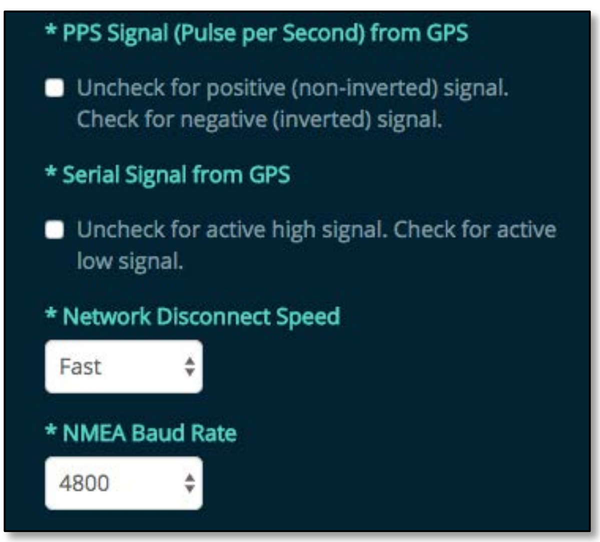

Figure 31. NMEA/PPS Signals as Settings to Edit

Timestamp

If we connect to the GPS receiver and turn it on, then the incoming NMEA/PPS signals can synchronize with the sensor.

- If the M8 sensor system is operating via the SDK *without a ROS driver*, the TCP packets are automatically UTC timestamped, as indicated in Table 5.
- If the M8 sensor system is operating via the SDK *with a ROS driver* or via the QPU (which is pre-configured with the ROS driver), a switch must be turned off in the config file (according to the following instructions) so that the UTC time in the TCP packet can be populated into the `/sensor/points` ROS topic.

Assuming the ROS driver is already installed and the GPS receiver is off and disconnected, turn off the config file switch and allow UTC timestamping, as follows:

1. Open a terminal window, and execute the following commands:
   ```
   $ roscd quanergy_client_ros
   $ cd settings
   $ sudo gedit client.xml
   ```
2. 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.
3. Display results from only the sensor 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.

   If you do not see that, execute the command `$ rostopic list`. Check the resulting list for the proper capitalization (`/sensor/points` or `/Sensor/points`), which varies with the sensor version. Re-execute the command `rostopic echo…` accordingly.

4. Display results with NMEA/PPS input by connecting the GPS receiver and powering it on. It takes up to thirty seconds for signals to fully synchronize with the sensor. Once synchronization takes place, you will see a display of the timestamp in real time:
   - Seconds counting up in Unix time (seconds elapsed since 1 January 1970).
   - Nanoseconds counting up 0 to 10^9, when it overflows and restarts count 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.

Appendix 2: Sensor Mounting Drawing

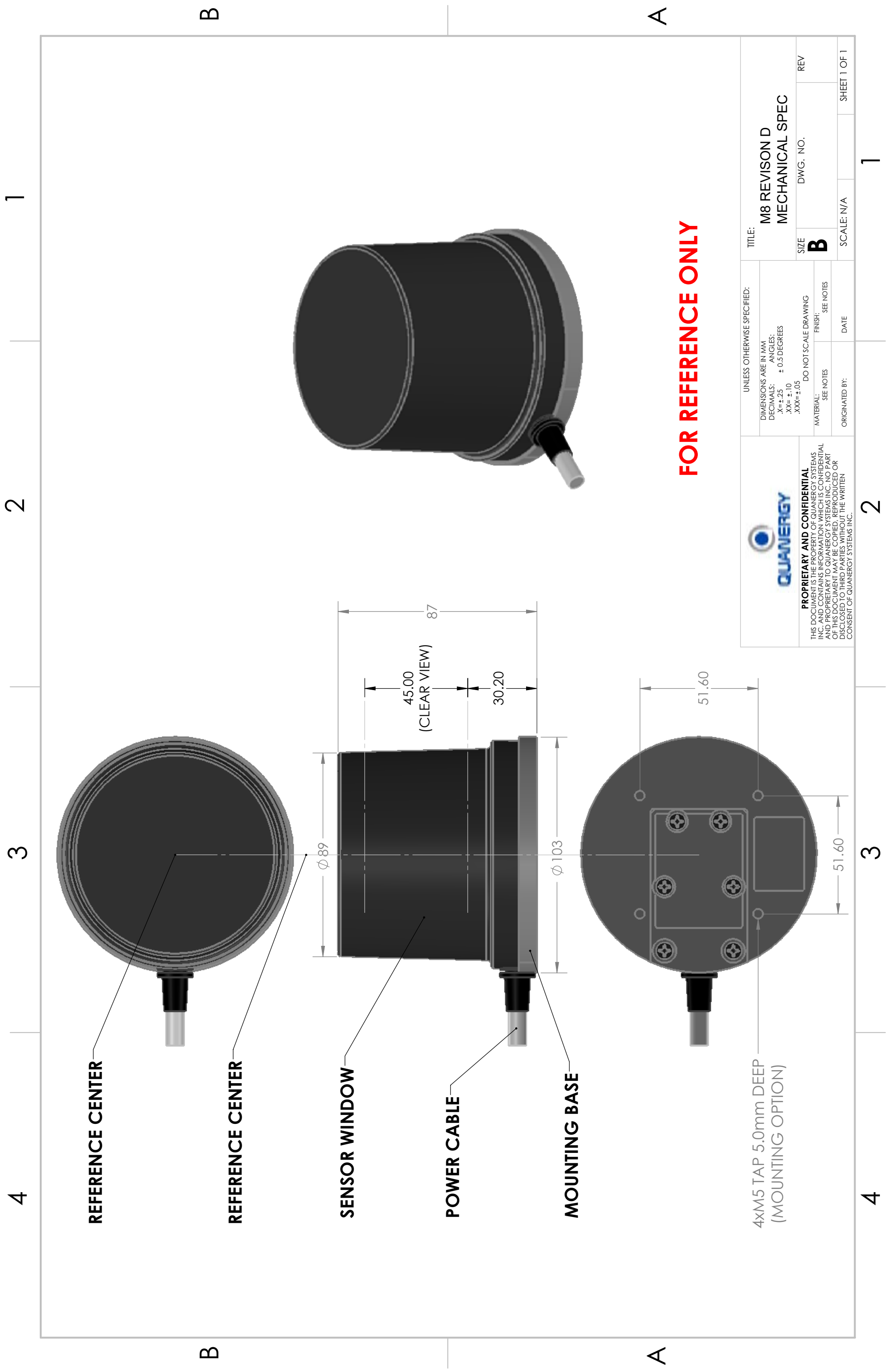

Figure 32. Sensor Mounting Drawing 1

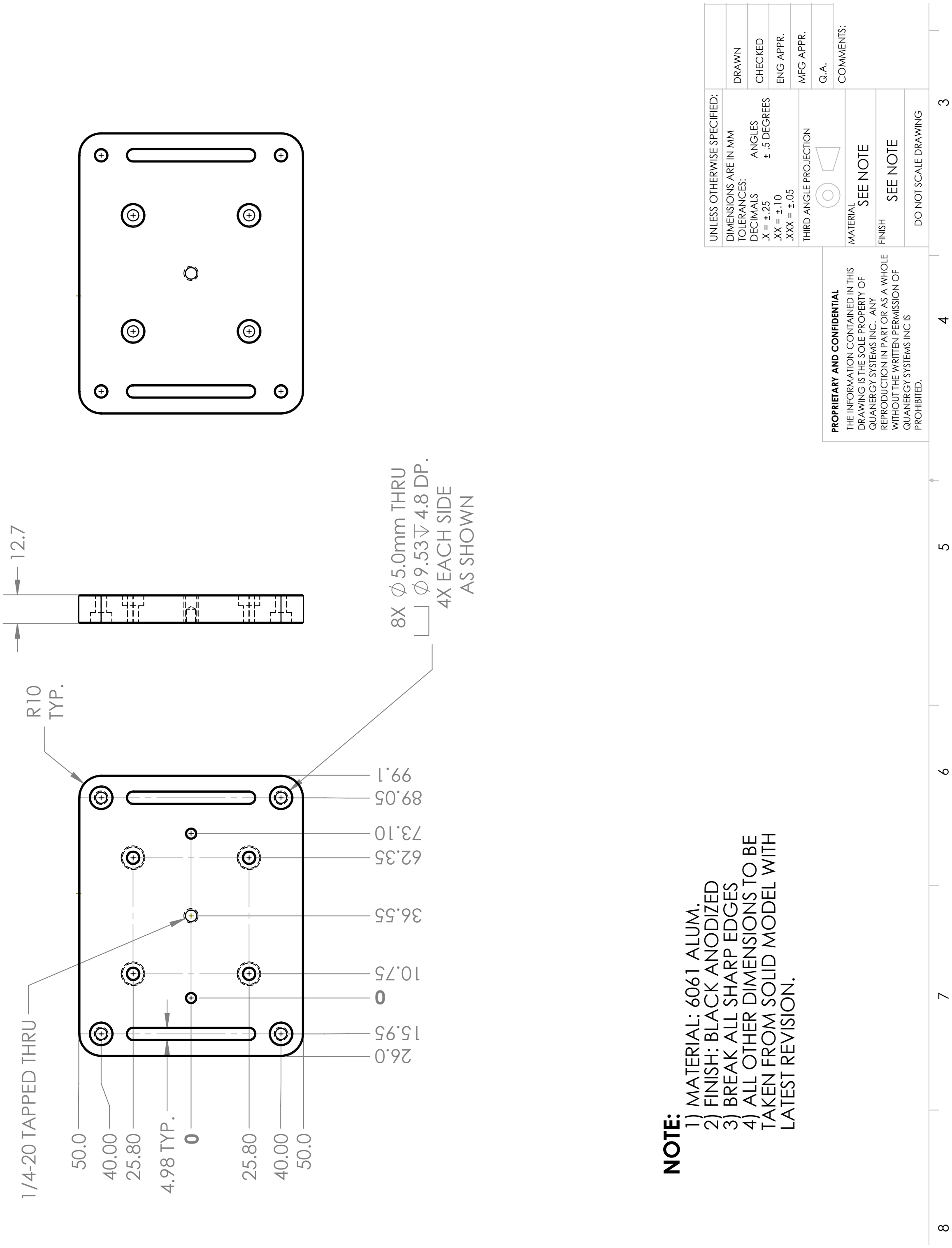

Figure 33. Sensor Mounting Drawing 2

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 V DC ± 4 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.

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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.

Specifications are subject to change without notice.